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Wastewater Technology Centre

Quarterly Project Update

January - March 1990

Technology Development Branch

Section de développement de technologies

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DIVISION: **BIOLOGICAL PROCESSES** **PROJECT MGR: H. MELCER**

PROJECT NO: 68101 **TEL: (416) 336-4546**

TITLE: **TECHNOLOGY SUPPORT TO REGIONAL OFFICES AND FEDERAL FACILITIES**

OBJECTIVE:

To provide technical support to C&P regional offices and Federal facilities with respect to biological technology for the treatment of municipal and industrial wastewaters.

RELEVANCE:

In support of all departmental priorities by providing technical support to regional offices and Federal facilities with respect to biological treatment processes.

WORK PLAN:

To provide, as requested, technical advice and program review to government personnel.
All regions have requested technical support in developing technology and process information to reduce the toxicity of pulp and paper sector wastewaters. These concerns are being addressed in project 29. Also, the Ontario regional office requires continuing support in the Ontario MISA program. This issue is being addressed in projects 03 and 04 (municipal sector), 05 (petroleum refinery sector, and 29 (pulp and paper sector).

STATUS REPORT - JUNE 1989

Western and Northern Region

At the request cf J. Harrison, C&P Saskatchewan District Office, a proposal for a wastewater treatment facility at a planned greenfield CTMP mill in Saskatchewan was reviewed. Comments were returned to the District Office.

At the request of F. Zaal, C&P Alberta District Office, E. Hall held discussions with staff of the Western Economic Diversification Program (WEDP) to offer technical support to a project involving ultrafiltration of selected CTMP pulp mill wastewaters. The project may be supported financially by WEDP as part of a larger package to develop and demonstrate new CTMP pulping technologies in Alberta. WEDP staff indicated an interest in obtaining assistance from the WTC for the management of the wastewater treatment portion of the study. Background material was forwarded to the WTC and reviewed by staff of the Biological and Physical/Chemical Processes Divisions.

Pacific and Yukon Region

Environment Canada sponsored a workshop on the treatment of CTMP effluents, held in Vancouver, April, 5,-7. As a result of the workshop, the WTC and PPRIC have agreed to develop a more comprehensive blueprint identifying research and technology demonstration needs in the CTMP sector. E. Hall prepared a technical summary of the Vancouver workshop and a draft outline for a national strategic CTMP wastewater treatment R&D program. The outline was forwarded to PPRIC for review and discussion with the CPPA Environmental Council.

Federal Facilities

At the request of A. Mauro, Department of Indian & Northern Affairs, Thunder Bay, H. Melcer reviewed the refit of an existing malfunctioning wastewater treatment plant in Northern Ontario.

STATUS REPORT - SEPTEMBER 1989

Federal Facilities

R. Jones and W. Bedford inspected the CFB Trenton Sewage treatment plant on 12 September at the request of the Federal Facilities Office Staff. The Ontario MOE had earlier banned land spreading sludge from the plant due to the low sludge nitrogen to mercury ratios. The purpose of the visit was to determine if any operational changes could lead to improvement in sludge quality. At a subsequent meeting with the MOE in Kingston, it was recommended that SRT control be implemented to minimize the long term accumulation of mercury in the sludge and to improve clarifier settling performance.

Western & Northern Region

Environmental Impact Statements for new CTMP mills in Meadow Lake and Nipawin Saskatchewan were reviewed by E. Hall. Comments on the proposed wastewater treatment facilities were forwarded to John Harrison, C&P Saskatchewan District Office.

H. Melcer reviewed proposals for a sewage treatment lagoon system at La Pas, Manitoba for EP Winnipeg office and for provision of toilet facilities at the Ellesmere Island National Park for CPS, Winnipeg.

Pacific & Yukon Region

BP Staff visited the Vancouver office on two occasions in September to provide updates on current research programs at the WTC and to evaluate requests for technical support in FY 1990/91.

STATUS REPORT - DECEMBER, 1989

Western and Northern Region

E. Hall visited the W&NR Office in Edmonton, on October 20 to review recent activities in CTMP effluent treatment R&D. Discussions were also held on the Alberta-Pacific bleached kraft mill proposal for Athabasca, Alberta.

At the request of C&P W&N Region, E. Hall attended the Alberta-Pacific Environmental Assessment Review Board hearings in Athabasca on November 17, 18 and 20, in Edmonton on December 4, and in Grasslands on December 7. Further technical support was provided for the preparation of material contained in an Environment Canada undertaking in response to questions raised by Alberta-Pacific.

E. Hall attended a meeting at the headquarters of Western Economic Diversification Canada (WED) in Edmonton on December 8. A consortium of eight Canadian CTMP mills has approached WED for funding assistance for the development of environmental protection technology for CTMP wastewaters. The initial review of the program was received positively by WED, and the consortium was asked to prepare a more detailed proposal for further consideration.

Industrial Programs Branch

A preliminary analysis was completed of data for British Columbia pulp and paper mills, collected under the Canadian Pulp and Paper Association National Dioxin Survey. A summary report describing the results was prepared and forwarded to RREPD/IPB and the C&P Regional Offices for review and comment. It was recommended that a similar analysis be undertaken when the data for all 47 Canadian bleached kraft mills are available later in 1990.

STATUS REPORT - MARCH 1990

WTC staff met with Simon Llewellyn and Tom Tseng, Ontario Region, to discuss data analysis issues related to the MISA program.

Ontario Region

E. Hall reviewed a report "Levels of AOX in Treated Wastewaters from Ontario Bleached Kraft Mills" prepared by C&P Ontario Region.

Western and Northern Region

Copies of the Environmental Impact Statement for the proposed BCTMP mill in Meadow Lake Saskatchewan, were received for review by Biological Processes and Residue Management Division staff. WTC comments were returned to D. Waite of the C&P Saskatchewan District Office.

Pacific and Yukon Region

At the request of L. Adamache, E. Hall visited British Columbia pulp and paper mills at Port Alice, Elk Falls, Powell River, Port Mellon and Woodfibre (Squamish). At each location, the results of recent on-site treatability programs were reviewed, and the companies' plans for full scale treatment facilities were discussed.

Industrial Programs Branch

E. Hall reviewed an interim report to IPB on "Background Study of Proposed Amendments to Pulp Industry Regulations on Organochlorines and Dioxins. Current Status of Industry, Ownership, and Effluent". Comments were returned to Alain Chung of RREP Division, IPB.

DIVISION: BIOLOGICAL PROCESSES **PROJECT MGR:** H. MELCER

PROJECT NO: 68103 **TEL:** (416) 336-4546

TITLE: FATE OF TRACE CONTAMINANTS IN BIOLOGICAL TREATMENT SYSTEMS

OBJECTIVE:

To determine the effectiveness of biological process technologies in removing trace contaminants from wastewaters.

RELEVANCE:

Increased pressure for toxic chemicals control has generated considerable information on the control of specific contaminants such as the Ontario EMPPL compounds, the U.S. EPA priority pollutants, chlorinated compounds and complex nitrogenous materials. Increasing evidence in the literature and from in-house work shows that biological systems are capable of achieving high levels of contaminant control.

This work responds to the requirements of the Technology Development and Technical Services Branch toxic chemical control activities and supports the Industrial Programs Branch needs in developing codes of practice for the control of trace contaminants in the municipal and industrial sectors.

WORK PLAN:

1) Work will be initiated to demonstrate the effect of SRT control on the removal of specific organic contaminants including 1,4-dichlorobenzene.

2) Technical support will be provided to the Ontario Ministry of the Environment in the development of their MISA program on an as required basis.

STATUS REPORT - JUNE 1989

1) Work on the fate of 1,4-dichlorobenzene (DCB) in municipal activated sludge systems was initiated. Analytical protocols were verified and three experiments were carried out at a 6-day SRT and a feed concentration of 50 µg/L under steady state conditions. Up to 70% of the DCB was found to be biologically removed.

2) A final report on the removal of trace contaminants in organic chemical industry wastewater treatment plants was completed for the Ontario Ministry of the Environment.

STATUS REPORT - SEPTEMBER 1989

1) Complete removals of 1,4-dichlorobenzene were demonstrated at influent concentrations of 100 and 250 µg/L. Unsteady state experiments are to be initiated in October. Extensive repairs were required to the air conditioning system in the toxics laboratory which resulted in a month's loss in experimentation.

Four sets of samples were collected of raw feeds and treated effluent at the Hamilton Wentworth STP in August. Samples were extracted and are undergoing analysis for PAHs and HNCs. The final report for Phase 3 of the toxics variability study was accepted from the contractor.

2) A draft report on the presence of toxic contaminants in petroleum refinery wastewaters was received from the contractor.

STATUS REPORT - DECEMBER 1989

1) Two unsteady state experiments were carried out on a system that was not acclimated to 1,4-dichlorobenzene. The dose of 1,4-dichlorobenzene was increased to 50 µg/L for a period of 23 hr. in the first experiment and 100 µg/L for a period of 18 hr. in the second experiment. Frequent samples of the exhaust air, mixed liquor and effluent were taken immediately after the step increase and decrease to establish the nature of the functions decreasing the rate of change in 1,4-dichlorobenzene in the three media. Mass balances showed that 75% of the 1,4-dichlorobenzene was stripped from solution. These observations confirmed earlier findings in non-acclimated systems that were receiving similar levels of 1,4-dichlorobenzene but on a continuous basis, that is, the preferential mechanism of 1,4-dichlorobenzene loss from non-acclimated systems is stripping. Earlier experiments demonstrated that once the systems are acclimated, the preferential removal mechanism is biodegradation. This observation will be verified using radio-labelled compounds for steady state and unsteady state conditions.

STATUS REPORT - MARCH 1990

1) Several fate experiments were conducted on 1,4-dichlorobenzene using parent compound and radio-labelled compounds. It was demonstrated that in unacclimated systems, the preferred loss mechanism is stripping whereas in acclimated systems, the preferred loss mechanism is biodegradation.

2) Support was given to the Ontario MOE in preparing the Sewer Use Evaluation Program specifically for the Hamilton-Wenthworth Region.

DIVISION: BIOLOGICAL PROCESSES **PROJECT MGR:** H. MELCER

PROJECT NO: 68104 **TEL:** (416) 336-4546

TITLE: MODELLING OF CONTAMINANT REMOVAL IN ACTIVATED SLUDGE SYSTEMS

OBJECTIVE:

To develop a PC computer-based model to forecast the removal of trace organic contaminants by activated sludge systems.

RELEVANCE:

With the development of regulatory programs for the control of toxic trace contaminant emissions from municipal wastewater treatment plants, there is an increasing need for tools that forecast the ability of these plants to remove the contaminants that are introduced into the municipal sewer system. With such a tool, regulators will be better able to implement a sewer use control program which will ensure that treated effluent quality is maintained at the desired level while simultaneously protecting the viability of the biological treatment entity. This work is in support of the Ontario MISA program.

WORK PLAN:

The project will be focused on the Ontario MISA EMPPL compounds. Candidate compounds will be selected for assessment of physical and chemical characteristics. Laboratory and pilot scale experiments will be carried out to provide data that are not available. Predictive models will be developed based on these data and the results of ongoing studies at the WTC.

STATUS REPORT - JUNE 1989

1) A draft report on the Phase 2 work on VOC emissions from municipal activated sludge systems was completed. The results of the last set of experiments at high SRTs and additional statistical analysis will be incorporated into the final report. Work was initiated on the development of the computer-based fate of contaminants forecasting model. Bench-scale activated sludge systems were started up and a literature survey initiated.

2) A survey was conducted of VOC emissions from an industrial facility treating organic chemical plant wastewaters. Techniques that were developed on municipal treatment plants were modified to address high strength wastewaters that were being treated in activated sludge systems with both diffused and mechanical aeration devices.

STATUS REPORT - SEPTEMBER 1989

A peer review committee was selected. Members included Dr. B. Rittmann of the University of Illinois, Dr. M. Berthoeux of the University of Wisconsin and Dr. S. Hrudey of the University of Alberta. The committee met at the WTC on 22 September. They made several recommendations that will require modifications to the experimental objectives and design and methods of data analysis. The most radical departure from the proposed experimental design will require the introduction of radio-labelled experiments to verify biological removal mechanisms in determining the fate of specific contaminants. A new computer data base was received from the U.S. EPA which will be reviewed and appropriate information will be extracted. Batch tests were carried out to determine metal sorption properties of primary sludge. Work on the development of software for the modelling programs was initiated.

STATUS REPORT - DECEMBER 1989

Additional batch and continuous metal sorption tests were carried out on primary and secondary sludges. Data from these tests are being analyzed and a report will be prepared in the coming quarter. Results from clean water pilot plant tests were inconsistent and samples are being reanalyzed. The pilot plant was seeded with Burlington Skyway STP sewage in October and equilibrated to a 3-day SRT. Experiments to assess the fate of pentachlorophenol and trichlorophenol were conducted in November and December respectively.

Improvements were made to the model by incorporating volatilization at clarifier weirs and a modified sorption terms. A computer based multi-response parameter estimation routine was received from the University of Western Ontario and incorporated in the model. Software was developed to improve user interface and the input and output formats.

Papers based on the forecasting abilities of the early version of the model were presented at the Annual WPCF and SETAC Conferences in October.

STATUS REPORT - MARCH 1990

A series of continuous flow fate of organics experiments were conducted in a 10 day SRT activated sludge system at pilot scale for chlorinated phenolics, selected VOCs and three pesticides (lindane, 3, 4-D and 2,4,5-T). For pentachlorophenol, complete removal was demonstrated without the formation of intermediate chlorinated species. This observation allowed fate experiments to be conducted with mixtures of penta-, tri- and monochlorophenol resulting in savings in analytical costs and time. Analysis of trichlorophenol and pentachlorophenol data from dynamic tests was carried out using non-linear regression to estimate treatability parameters. A good fit of the model to the data was obtained.

Companion experiments were carried out with C^{14} - labelled toluene, chloroform and 1,4-dichlorobenzene in bench-scale activated sludge systems.

Data from batch and continuous tests to determine metal sorption properties are still being analyzed.

DIVISION: BIOLOGICAL PROCESSES **PROJECT MGR:** D.T. CHAPMAN

PROJECT NO: 68105 **TEL:** (416) 336-4621

TITLE: STATISTICAL EVALUATION OF PERFORMANCE DATA

OBJECTIVE:

To evaluate and demonstrate techniques for analyzing and displaying data from wastewater treatment plants for both conventional and trace contaminants.

RELEVANCE:

Effluent data from wastewater treatment plants are evaluated to establish whether a plant complies with effluent standards or guidelines, to estimate mass discharge rates of a pollutant, to determine if there is a trend in the effluent data, or to establish if a control action has affected process performance. Frequently, however, such data are noisy, contain missing values, are highly skewed with a non-normal distribution and are serially correlated. In addition, toxic trace organic data often contain "non detects", indicating that the sample contains a concentration which is below the detection limit of the analytical technique. These characteristics often invalidate the use of conventional statistical procedures which are based on assumptions of normality and independence. Simple and effective techniques are therefore required to enable operators and engineers to summarize, display and analyze effluent data.

WORK PLAN:

1) The proceedings from the workshop, "Statistical Methods for the Assessment of Point Source Pollution", will be edited and published.

2) Based on the outcome of workshops held on March 6 & 7, 1989 (sponsored by PACE, API, and CAWPRC), assistance will be provided to the petroleum refinery sector concerning the management and analysis of wastewater treatment plant data.

3) Support will be provided in the development of a short course on time-series analysis for effluent and water quality data. The course will be prepared by K.W. Hipel, University of Waterloo, and A.I. McLeod, University of Western Ontario.

STATUS REPORT - JUNE 1989

1) Workshop Proceedings:- Review of the papers for the proceedings was completed and revised papers were forwarded to the editors of the journal Environmental Monitoring and Assessment (EMA).

2) Petroleum Refinery Data:- Meetings were held with the Ontario Petroleum Association (OPA) to discuss the scope and feasibility of developing a MISA database for the 7 Ontario petroleum refineries. A diskette of MISA data (input using the Ministry of Environment's MIDES program) was obtained from Petro-Canada's Mississauga refinery and software written for reading this data into WTC's minicomputer. A preliminary set of forms was designed for summarizing results on a monthly and quarterly basis. The reports will enable individual refineries to review their MISA data and provide a synopsis of industry-wide results. These reports were reviewed and revised by the OPA at a meeting on June 22. A number of technical issues discussed at this and earlier meetings indicated the need for supplementary studies to aid in the interpretation of the MISA results.

A proposal was prepared outlining a cooperative research project between the OPA and WTC to develop a database containing the MISA monitoring results for the 7 Ontario petroleum refineries and, subsequently, to summarize and analyze the data. The project work plan consists of the following major components:

a) acquire the MISA data from the seven Ontario petroleum refineries and develop a database on WTC's minicomputer;

b) generate monthly and quarterly reports;

c) generate graphical displays of the MISA database for a selected number of chemicals and plants;

d) identify and conduct special studies for the analysis and interpretation of results contained in the database.

The nature and extent of the special studies and the project schedule will be re-evaluated once reports for the first 6-months of data have been generated.

3) Time-Series Short Course:- Professor Hipel, University of Waterloo, confirmed that a short course on time-series analysis for effluent and water quality data will proceed. The course will held at the University of Western Ontario, London, in December 1989.

STATUS REPORT - SEPTEMBER 1989

1) Workshop Proceedings:- A glossary of statistical terms and preface were mailed to the publisher for inclusion in the proceedings. The proceedings are now complete.

2) Petroleum Refinery Data:- The 7 Ontario petroleum refineries were asked to forward to WTC diskettes of the MISA data stored in the MIDES format for the period from December to May. The data was uploaded to the HP-1000 for inclusion in the database. Refineries late in submitting the diskettes were contacted by phone.

Programming was initiated with the objective of producing tabular summaries of the OPA MISA data for the period December to May. Summary tables for individual plants and for the industry as a whole were printed out and distributed to the refineries. A review of the industry-wide summaries was initiated.

The refineries were also asked to supply a flow schematic which identifies how the various wastewater streams combine prior to discharge to receiving waters. Discharge flow logic diagrams were constructed for each of the refineries using DRAWIT. In addition, tables were prepared identifying which wastewater unit processes are used at each refinery, the type of chemicals added during or following wastewater treatment, the refinery sub-category according to U.S. EPA criteria, and the number and type of wastewater discharges. A standardized terminology was adopted for process streams and wastewater unit processes.

A meeting was held with OPA's MISA Technical Committee on September 6 to review the status of the work and the goals for the next period.

U.S. EPA development documents for effluent limitations for petroleum refineries and for the organic chemicals, plastics, and synthetic fibres point sources were obtained.

3) Other:- The final draft of the report "Evaluation of Estimates of Phosphorus Concentrations and Loadings from Ontario Municipal Wastewater Treatment Plants" was submitted to the MOE and accepted.

STATUS REPORT - DECEMBER 1989

1.) Workshop Proceedings:- The preface to the proceedings was reviewed and returned to the publisher.

2.) Petroleum Refinery Data:- An initial review was conducted of the OPA data (for the period Dec.- May) summarized in tabular form. The review identified format revisions to the tabular summaries and listed anomalies in the data set based on industry-wide comparisons. The review comments were summarized in a brief report, "OPA MISA Database: Preliminary Analysis of Industry-Wide Summary (Dec.- May)". Following a project meeting with members of the Ontario Petroleum Association, Oct. 10, revisions were made to the format of the 6-month data tables. A summary of the report calculation methods and comments in interpreting the data tables was also prepared. The revised industry-wide 6-month data tables were mailed to the 7 refineries in Dec.

A presentation on the development and management of the MISA petroleum refinery database was given at the MISA Laboratories's Q.A. and Analytical Methods Workshop held in Toronto, November 28 and 29. Included in the presentation were results of a telephone survey of the refineries regarding their experiences with the MIDES, Version 4.1, data entry program.

A meeting was held on Dec. 1 with MOE staff to review procedures and issues involved in the analysis of the MISA data for the petroleum refinery sector. Issues discussed included potential use of characterization data for compliance setting, handling of data flagged by a MIDES comment code, use of field QC data, and assumptions regarding values for "non detects".

3.) Other:- In Nov., discussions were held with Dofasco personnel concerning MISA data management and analysis techniques. WTC staff also met with representatives of the Ontario Forest Industry Association to review the OPA program and discuss a potential project for the 27 pulp and paper mills which are to be monitored under the MISA program as of Jan. 1, 1989.

Minor revisions were made to the paper titled "Management and Analysis of Data From Petroleum Refinery Wastewater Treatment Plants".

STATUS REPORT - MARCH 1990

1.) Workshop Proceedings:- The proceedings of the workshop, Statistical Methods for the Assessment of Point Source Pollution, were published in the journal Environmental Monitoring and Assessment, (volume 12), December, 1989 and as a separate hardcover book. Copies of the book were distributed to members of the Workshop Organizing Committee.

2.) Petroleum Refinery Data:- Additional data diskettes were received and uploaded to the HP-1000. The plant-specific and industry-wide 9- and 12-month data tables were generated, reviewed, and distributed to the individual refineries. Summaries of anomalies or missing data were compiled and appended to the 12-month data tables. A revised methodology was developed for computing loads, concentrations, and flows when a refinery has more than one discharge per stream type (ie. more than one once-through cooling water stream).

Based on review of the summary data tables, additional summary statistics and comments were prepared and presented in "Preliminary Report: MISA Monitoring Results for Ontario Petroleum Refineries For the Period December 1, 1988 to November 31, 1989". The first draft of this report was forwarded to the Ontario Petroleum Association (OPA) for review and comment.

Preliminary work was initiated to summarise the field QC data (field blanks, spikes, and duplicates). Frequency of detection (FOD) tables were generated for the field blank results. Cases with FODs of 15% or more were selected for more detailed examination.

Using U.S. EPA data analysis practices, spreadsheets were developed to examine the effect of different substitution practices on long-term averages, daily variability factors, and daily limits for benzene, and oil & grease for all seven Ontario refineries. The substitution procedures included: a.) <LMDL = LMDL, b.) <LMDL = 0., c.) <LMDL = RMDL/10., d.) <RMDL = RMDL, e.) <RMDL = RMDL/10., f.) <RMDL = 0. where LMDL is the laboratory method detection limit and RMDL is the regulated method detection limit required under the MISA program.

A program review meeting was held with OPA personnel on Feb. 6 in Sarnia.

3.) Other:

A proposal, "Development and Analysis of a MISA Database for Ontario Pulp and Paper Mills" was prepared and submitted to the Ontario Forest Industries Association (OFIA). On Jan. 26, a meeting was held with the Brian Young and Doug Pryke, OFIA, to review the proposal and a draft of the Memorandum of Understanding. The MOU and proposal was subsequently revised and submitted to the OFIA. A list of preliminary information requirements required to design the OFIA database was drawn up.

A meeting was held with representatives from the Lambton Industrial Society to discuss a possible project to organize a database of effluent trace organics discharged by industries in the Sarnia area.

DIVISION: BIOLOGICAL PROCESSES **PROJECT MGR:** D.T. CHAPMAN

PROJECT NO: 68106 **TEL:** (416) 336-4621

TITLE: OPERATIONAL WASTEWATER TREATMENT MODELLING

OBJECTIVE:

To develop and validate simple wastewater treatment models to be used for real-time operation and control.

RELEVANCE:

Municipal and industrial wastewater treatment plants are subject to changes in environmental conditions and transients in hydraulic, organic, and toxic loads which cause excursions in effluent quality. Simulations with dynamic models of wastewater treatment plants enable operators to evaluate and verify control strategies before implementation. However, existing models, such as the one developed by the IAWPRC, are generally unsuitable for use in operating treatment plants. Because of the number and type of variables contained in the models, model coefficients cannot be estimated from actual data collected from treatment plants.

Improved performance of wastewater treatment plants requires the development of simplified models which achieve a balance between a description of fundamental biological, chemical, and physical mechanisms and the ability to calibrate the model using treatment plant data. Research is proposed to develop simplified models for improving treatment plant operation by analyzing the sensitivity of model parameters as the models are subject to inputs over a wide spectrum of inputs and developing an expert system to extract operating rules from dynamic models.

WORK PLAN:

1) Common operational problems will be identified by interviewing plant operators and reviewing the operator training literature. Based on the results, a database will be developed for use with an expert system.

2) A survey will be conducted of the control and chemical engineering literature on hierarchical model development.

3) An existing library of dynamic models for wastewater treatment plants will be reviewed and updated.

4) A systematic analysis will be conducted of model parameter sensitivity.

STATUS REPORT - JUNE 1989

A seminar, "Biological Phosphorus Removal: Modelling a Complex Biological Process" was presented by Dr. Imre Takács, McMaster University, to WTC and McMaster University staff.

The book, Dynamic Modeling and Expert Systems in Wastewater Engineering, was edited and additional definitions were added to the glossary. The completed draft was forwarded to the publisher.

STATUS REPORT - SEPTEMBER 1989

Editing of Dynamic Modelling and Expert Systems in Wastewater Engineering was completed and the final manuscript forwarded to Lewis Publishers, Inc. The book was published in August and copies distributed to editors, authors, and workshop participants.

Work was initiated on the development of a Kalman filter formulation of a secondary clarifier model originally developed by Vitasovic. The model will be used to simulate the time-varying behaviour of clarification and thickening in secondary clarifiers. A literature review was initiated in the interactions between wastewater collection systems and treatment plants.

Work continued on a new version of the Screen Oriented Modelling Interface (SOMI) and modifications were made to the model library to meet the requirements of ACSL, Release 9. A simplified model of the Hamilton Wastewater Treatment Plant was assembled to study secondary clarifier dynamics. Enhancements were made to the biological phosphorus model. A draft of the User's Manual for the General Purpose simulator was written.

Software was programmed to link the results from dynamic models to expert systems. Preliminary results indicated the utility of using dynamic models to evaluate expert system-assisted operation.

Dr. Imre Takács presented a paper on SOMI at a conference in Austin, Texas.

STATUS REPORT - DECEMBER 1989

Data was collected at the Hamilton WWTP during various storm flow conditions to test the dynamics of the clarification and thickening models contained in the General Purpose simulator. Work was initiated to calibrate the models using Simulsov, a parameter identification program. A number of problems were encountered with the program and Dow Chemical, the developers of the package, were contacted. A review of anaerobic digester models was completed and three models were adopted for the library.

No expert system development work was conducted. Editing of a report on expert system-simulation interactions is proceeding.

STATUS REPORT - MARCH 1990

G. Speirs and D. Chapman met with G. Patry, McMaster University, on Jan. 24 to discuss the status of funds and activities for the existing project. Potential follow-up project activities were also reviewed.

DIVISION: BIOLOGICAL PROCESSES **PROJECT MGR:** H. MELCER

PROJECT NO: 68107 **TEL:** (416) 336-4546

TITLE: BIOFOULING OF FINE PORE DIFFUSERS

OBJECTIVE:

To examine the microbiological processes that contribute to the development of biofilm accretions on fine pore oxygen transfer aeration devices in activated sludge systems.

RELEVANCE:

The advent of fine pore diffusion aeration devices allowed large improvements to be made with respect to oxygen transfer efficiency. This offered the potential of reduced capital expenditure for new and upgraded treatment plants. Unfortunately, in some installations, biofouling of the surfaces of these fine pore devices has resulted in an accompanying decline in oxygen transfer efficiency and increased maintenance costs. The reasons for the incidence of biofouling are not understood. This research addresses the needs of municipalities and design engineers who wish to install these energy-saving devices but also need guidance with respect to the type of conditions that induce fouling.

WORK PLAN:

Measurements of biofilm properties and diffuser process characteristics will be carried out at six-monthly intervals of two pilot diffuser systems that were installed in January, 1989.

STATUS REPORT - JUNE 1989

Sacrificial sample diffusers were removed from each of the Monroe and Milwaukee, Wisconsin plants in May. This followed a period of 5 months immersion under test conditions. The test structures fared well during this period with less corrosion than had been anticipated. The sample diffusers demonstrated completely different fouling tendencies with thick biofilms observed at Milwaukee and minimal sliming at Monroe. The diffusers were sent to the University of Calgary for electron microscopy analysis and to Ewing Engineering for diffuser characterization.

The development of biofilms on carbon carrier particles in a simulated high-rate anaerobic reactor was followed by electron microscopy procedures. It was demonstrated that biofilms were established within 2 days of reactor start-up.

STATUS REPORT - SEPTEMBER 1989

A second round of test diffusers were sampled in September. The nature of the biofilms had changed considerably since the first sample period. The thick biofilms of Milwaukee had sloughed off whereas thicker biofilms were observed at Monroe. SEM analysis of the first samples had confirmed the presence of a honeycomb of structured air passages within the biofilm of the type which had been observed in earlier work. Data from Ewing Engineering and Dr. Costerton will be analyzed in preparation of a project review to be held mid-November.

STATUS REPORT - DECEMBER 1989

Contractor reports on the September sampling period have not been received.

STATUS REPORT - MARCH 1990

The third of a series of fine pore diffuser samples were removed from test sites at the Milwaukee and Monroe STPs in February. Analysis of the data on biofouling of the diffusers over the whole sampling period is in progress.

DIVISION: BIOLOGICAL PROCESSES **PROJECT MGR:** H. MELCER

PROJECT NO: 68108 **TEL:** (416) 336-4546

TITLE: MODIFICATION OF EXISTING AEROBIC SLUDGE DIGESTERS TO INCORPORATE ATAD TECHNOLOGY

OBJECTIVE:

To evaluate the technical and economic feasibility of modifying existing aerobic sludge digesters to incorporate autothermal aerobic digestion (ATAD) technology.

RELEVANCE:

In small communities of less than 10,000 persons, municipal wastewater treatment plant sludges are normally digested aerobically. This is becoming an increasingly expensive method of stabilizing sludges in view of escalating energy costs. More importantly, the digestion process has to occur over a 20 to 60 day period to meet regulatory requirements for pasteurization. The ATAD technology can achieve a similar product in a 4 to 6 day period. Such a modification offers considerable economic savings. This work addresses the needs of federal facilities and also those small municipalities that practice aerobic sludge digestion of which there are a large number in British Columbia.

STATUS REPORT - JUNE 1989

A failure of the sludge recycle pump controller at the Salmon Arm ATAD caused too much sludge to be transferred to the ATAD. The operating temperature fell from 58°C to almost ambient temperature. Once the controller was repaired, the ATAD temperature rose to 62°C with 24 hours demonstrating remarkable resilience and recovery characteristics of the microflora.

The Ladysmith ATAD demonstration site was visited on 3 May for a project review meeting. The Ladysmith plant is fully commissioned but is suffering from an inconsistent supply of sludge from the primary settler/digester. The Salmon Arms ATAD has returned to normal operation at 60°C as has the Gibsons Landing ATAD. Microbiological testing to evaluate the degree of pasteurization was initiated in June.

STATUS REPORT - SEPTEMBER 1989

The Gibson ATAD System was visited in September for a project review meeting. The sludge supply to the Ladysmith ATAD was rectified. All three ATAD sites reported pathogen destruction to below detectable limits. Minimal odour problems have been reported. Dewaterability of the digested sludges is variable at the three test sites. A major flaw in the experimental design was identified. Sludge generation rates that were given to the contractor were underestimated by a factor of two at all three test sites resulting in reactor residence times ranging from 10 to 18 days. Sampling was revised to address the discharge of the first stage of the ATAD reactors at all test sites to provide a test residence time approaching the desired five day retention time.

STATUS REPORT - DECEMBER 1989

The sampling programs at the three test sites were terminated at the end of December. A report based on the results from the three sites will be prepared by the contractor during the next quarter.

STATUS REPORT - MARCH 1990

The last portion of work addressing the assessment of the Gibson's ATAD system was completed in February. A draft report is in preparation.

DIVISION: BIOLOGICAL PROCESSES **PROJECT MGR:** E.R. HALL

PROJECT NO: 68109 **TEL:** (416) 336-4546

TITLE: BIOLOGICAL TREATMENT OF CONTAMINATED GROUNDWATERS

OBJECTIVE:

1) To become cognizant of the state of the art and current research activities regarding biological treatment of contaminated groundwaters.

2) To develop a program that investigates the application of biological processes to contaminated groundwaters.

RELEVANCE:

It has been demonstrated that instances of contaminated groundwater exist in Canada. Programs have been initiated to examine the effectiveness of physical-chemical unit operations in the remediation of contaminated groundwaters. Extensive work is being pursued in the U.S.A. on in-situ and above ground biological treatment of contaminated groundwaters. It is appropriate that biological treatment be evaluated as an alternative treatment option.

WORK PLAN:

1) To review pertinent literature and meet with appropriate researchers to establish the status and degree of success achieved with in-situ and above ground biological treatment systems.

2) To develop a program of investigations for FY 1990/91.

STATUS REPORT - JUNE 1989

H. Melcer attended a USEPA-sponsored groundwater and soil remediation workshop in Oklahoma City in June. Three days' of presentations were made by EPA contractors on the status of their research programs. The EPA research effort in this field is focused upon the R.S. Kerr Laboratory in Ada, OK and the Universities of Oklahoma, Utah and Stanford. The major investigations into in situ biological remediation of contaminated groundwater are being conducted by USEPA contractors at Traverse City, Michigan and Stanford University. The USEPA has also sponsored a collaborative venture between sister laboratories in Cincinnati, Ada, Gulf Springs, Athens and Duluth to carry out process-related investigations into biological remediation of groundwater and soil contaminated with hazardous chemicals. It is proposed to merge WTC's research program with this joint venture.

STATUS REPORT - SEPTEMBER 1989

Meetings were held with the R.S. Kerr Laboratory in September to discuss potential joint research programs. It was suggested that an area that would be useful to the U.S. EPA was that requiring remediation of groundwater contaminated by agricultural pesticides. A soil remediation workshop organized by the Utah State University (USU) was attended in August. It was evident that the research team at USU had extensive expertise and experience in the biological remediation of soils contaminated with PAHs and phenolics residues typically found at abandoned coal gasification sites. Their expertise maybe useful in a secondary phase of remediation at the abandoned coal tar ponds in Sydney, N.S. once the incineration of the most contaminated residues are completed.

Attendance at a U.S. EPA Contractors' Hazardous Waste Conference in Pittsburgh in September demonstrated the extensive multi-million dollar research program that has been initiated by the SITE Remediation Program. Technologies that are under evaluation by the U.S. EPA range from physical through biological to total destruction. It was evident that no expense is being spared in evaluating technologies for the remediation of contaminated groundwaters and soils. It was also evident that many projects were not of high technical calibre, lacking in adequate experimental design and analysis of data.

STATUS REPORT - DECEMBER 1989

No activity to report.

STATUS REPORT - MARCH 1990

Proposals for in situ bioremediation of groundwater and soils were reviewed at the GasRep In Situ Bioremediation subcommittee meeting in January.

DIVISION: BIOLOGICAL PROCESSES **PROJECT MGR:** G. SPEIRS

PROJECT NO: 68112 **TEL:** (416) 336-4745

TITLE: OPTIMIZATION OF AUTOMATED CONTROL SYSTEMS FOR MAXIMIZING ENERGY SAVINGS AND PLANT CAPACITY AT FULL-SCALE ACTIVATED SLUDGE WASTEWATER TREATMENT FACILITIES.

OBJECTIVE:

1) To determine optimum control strategies for automated process control systems to maximize aeration energy savings and plant throughput capacity while meeting performance and reliability criteria.

2) To further develop and demonstrate procedures to fully utilize computing capacity to determine, flag and minimize the need for on-line instrumentation maintenance.

RELEVANCE:

As part of its mandate to investigate cost-efficient solutions to wastewater treatment, the WTC has investigated the use of on-line instrumentation and microprocessor-based controllers for automated process control in biological wastewater treatment systems. Energy savings and improved process control through the automated control of dissolved oxygen (DO) concentration and biological solids inventory have been demonstrated by the WTC at pilot scale and, more recently, at a full-scale activated sludge treatment plant. Operation of two parallel treatment trains at the refitted Tillsonburg, Ontario activated sludge wastewater treatment plant has confirmed aeration energy savings ranging from 15 to 35 percent for automated versus manual aeration control, depending on the level of manual control. In addition to reducing operating costs, the incorporation of automated control strategies can optimize the capacity of existing facilities and postpone unnecessary plant expansions, thereby saving potential capital expenses. Preliminary experimentation at Tillsonburg has shown that with automated control, half of the existing aeration tankage is capable of handling the entire plant throughput.

While it has been demonstrated that automated control algorithms can tightly control process parameters such as DO to setpoint values, there is a need to investigate the selection and manipulation of setpoints to maximize energy savings and effective plant capacity while maintaining process reliability and control. Also, further development of methodologies which take full advantage of control system computing power to determine, flag and predict the need for on-line instrumentation maintenance are needed.

WORK PLAN:

1) Complete the documentation of comparative automated versus manual aeration control experimentation. Prepare final report for PERD and U.S. EPA.

2) Complete documentation and final report on instrumentation maintenance investigations completed to date as part of 1) above. To further investigate on-line techniques for minimizing on-line instrumentation maintenance.

3) Conduct experimentation to determine how setpoint values for such operating parameters as DO and solids retention time (SRT) should be selected and manipulated to maximize energy savings and plant operating capacity while ensuring process performance and reliability.

4) To develop a methodology for determining the in-situ performance of fine pore aeration devices at Tillsonburg in consideration of optimizing the unit process operation for maximum treatment plant capacity.

5) To complete the documentation of the assessment of on-line aeration equipment performance evaluation techniques. Prepare final report.

STATUS REPORT - JUNE 1989

Report preparation continued. A final draft will be submitted to U.S. EPA in July to fulfil the deliverable requirement of the cooperative agreement. Final editing to be complete in the next quarter.

Tillsonburg WPCP instrumentation and control system has continued to perform well. Plant performance has been excellent; although continued interruptions in the hauling and disposal of digested sludge has resulted in sludge inventory buildup. The increased loading due to excessive digester supernating and, essentially sludge recirculation, has put considerable stress on the SRT and aeration control system.

STATUS REPORT - SEPTEMBER 1989

Final report preparation/editing continued.

The Tillsonburg WPCP I & C system continued to perform well. Plant performance has been excellent.

A group of plant superintendents and senior operators from the Regional Municipality of Halton met at the plant to review control strategies and operation of the I & C system.

A presentation entitled "Installation - Not The Whole Problem" outlining some of the problems experienced at start-up of the Tillsonburg project was made as part of the Instrumentation Testing Association (ITA) Flow Measurement Workshop held at the CCIW on the 12, 13 September.

STATUS REPORT - DECEMBER 1989

Final report preparation/editing continued. The report is expected to be completed early next quarter.

The Tillsonburg WPCP I & C system continued to perform well. Replacement of the sludge flights in the South train primary settling tank combined with interruptions in sludge hauling and excessive digester supernating, led to a buildup of solids in the aeration trains. The control system maintained dissolved oxygen and solids control minimizing adverse affects on process effluent.

STATUS REPORT - MARCH 1990

WTC continued to maintain the I & C system at Tillsonburg in an operational mode pending final decisions on decommissioning of project and handback to the MOE. Preliminary discussions on handover and the required modifications to the system were initiated.

The aeration control system at the Tillsonburg plant was interrupted due to component failures in the a.c. variable frequency drive and the replacement of dissolved oxygen probe cells in the South process train. The DO cells had been in service for approximately two years - far exceeding the expected life span of one year.

One channel of one of the two DO multiplexers failed in March. The repair of the unit and software modifications to bypass the problem have been deferred until the overall project direction is clarified.

Final report preparation continued and is expected to be completed in May.

DIVISION: BIOLOGICAL PROCESSES **PROJECT MGR:** G. SPEIRS

PROJECT NO. 68115 **TEL:** (416) 336-4745

TITLE: TECHNICAL SUPPORT AND TECHNOLOGY TRANSFER FOR OPTIMIZING OPERATIONS IN AEROBIC BIOLOGICAL WASTEWATER TREATMENT SYSTEMS

OBJECTIVE:

To transfer technology developed by the WTC for optimizing operational control of biological wastewater treatment systems to users and agencies through the provision of technical assistance and advice in both industrial and municipal sectors.

RELEVANCE:

The WTC has experience with optimizing operational control of wastewater treatment processes, particularly through the implementation of computer-based automated control systems. One of the critical factors in successfully implementing these systems, is the effective incorporation of on-line instrumentation with appropriate automated control strategies. The WTC's experience with on-line instrumentation-based process control is available to ensure that cost-efficient operation of wastewater treatment facilities is achieved.

WORK PLAN:

1) To provide technical assistance and support, on an as requested basis, to users implementing control strategies and on-line instrument-based systems for improved wastewater treatment plant operations. These agencies include: the Regional Municipality of Halton; the Municipality of Metropolitan Toronto; the City of Edmonton; and the City of Windsor.

2) The continued participation of WTC staff in the ongoing WTC / Swedish VAV technical exchange program .

3) WTC personnel will continue to interact with, and provide technical assistance, as requested, to the Water and Wastewater Instrument Testing Association for North America (ITA) in the evaluation of on-line instrumentation for wastewater treatment applications.

STATUS REPORT - JUNE 1989

D. Chapman met with D. Lumley, Chalmers University of Technology (Gothenburg, Sweden), to finalise discussions concerning the translation and editing of a report on wastewater treatment plant automation and instrumentation prepared by working group TR39 of the Swedish Water and Wastewater Association (VAV). Editing of the translated version was initiated.

Information was provided to Harlan Kelly (Dayton and Knight), Hugh Monteith (Ontario Ministry of Environment) and Len Yust (Region of Halton) concerning work carried out at the Wastewater Technology Centre by Profs. Silveston and Hudgins of the University of Waterloo. In 1982, an evaluation was conducted of the performance of an 8' diameter clarifier (WTC's PP#1) which had been retrofitted with a proprietary baffle.

The technical program for the Water and Wastewater Instrumentation Testing Association (ITA) Flow Measurement Workshop was completed. The workshop is jointly sponsored by ITA and WTC, and will be held at CCIW, Burlington, September 12-13, 1989. The workshop will address issues such as regulatory policies, flow measurement devices and their selection, modelling and conformance flow estimating techniques. Registration and workshop logistics are being directed by Jean Stafford, WTC 416/336-4598.

WTC personnel made presentations on process control and operations optimization, and anaerobic treatment technology at a CWWA sponsored one-day technical seminar in Halifax. Similar presentations were also made at the U.S. EPA 1989 Municipal Wastewater Treatment Technology Forum held June 6-8 in Ann Arbor, MI.

The interim report of results from the first data collection phase ("dry weather" conditions) of the plant capacity and process and operations audit at the City of Windsor's Little River WPCP was tabled by the consultant for review by the Technical Steering Committee. The results of preliminary data analyses of data collected during the second phase ("wet weather" conditions) were also presented to the technical steering committee.

The MOE technical advisory subcommittee set up to determine the current status of flow monitoring and sampling at Ontario WPCP's, has received completed questionnaires from some 280+ of the 400+ Ontario WPCP's. The committee met to assess the data base requirements for appropriately handling the responses.

Final edits were made to the chapter on aeration control for the USEPA/ASCE Fine Pore Aeration Design and Operation Manual. USEPA/ASCE have planned workshops for selected locations in North America in 89/90 to disseminate the project results. Preparation of presentation material for these workshops has been initiated.

STATUS REPORT - SEPTEMBER 1989

Chapters 1-10 of the second draft of the English version of VAV's TR39 report were edited. Additional terms were identified for inclusion in the glossary.

Planning was initiated concerning topics, speakers, and participants for the VAV/WTC exchange workshop. The workshop will be held in Kelowna, B.C., on October 23-24 following the annual conference of the Water Pollution Control Federation in October. Presentations on biological phosphorus removal and the process audit work were given in conjunction with site inspections of the Kelowna and Penticton WTPs. Representatives from the cities of Calgary, Edmonton, Saskatoon, and Regina were invited to the workshop.

The ITA Flow Measurement Workshop was held at CCIW 12-13 September. The workshop was well attended and considered to be very successful.

The plant capacity and process operation audit at the City of Windsor's Little River WPCP continued with the completion of the third and final data collection phase. Preliminary results were presented to the steering committee. The final report will be completed in the next quarter.

A presentation entitled "Automated Aeration Control" was made as part of the U.S. EPA/ASCE Fine Pore Aeration Designs and Operation Seminar held in Philadelphia 15 - 16 August. The seminar was very successful and will be repeated in Chicago and San Francisco 13 - 14 November and 15 - 17 November respectively. It is anticipated that the two-day seminar will be held at CCIW 13 - 14 March, 1990.

STATUS REPORT - DECEMBER 1989

The 1989 VAV/WTC technical exchange seminar on biological phosphorus removal was held in Kelowna, B.C., Oct. 23 and 24. In addition to VAV and WTC staff, there were participants from U.B.C., McMaster University, WRc (Swindon), NovaTec Consulting Engineers, Stanley Consulting Engineers, B.C. Ministry of Environment, Okanagan College and the cities of Edmonton, Regina, Saskatoon, Kelowna, and Penticton. In conjunction with the seminars, inspection trips for the participants were arranged for the Kelowna, Westbank, and Penticton WWTPs.

The final report prepared by the consultant for the plant capacity and process operation audit at the City of Windsor's Little River WPCP was completed. The Technical Steering Committee will meet in January to review the report and table recommendations. A presentation on the results of the Little River WPCP audit, and operational auditing in general, was made as part of the VAV/WTC Kelowna workshop.

The presentation entitled "Automated Aeration Control: was made as part of U.S. EPA/ASCE Fine Pore Aeration Designs and Operation Seminars held in Chicago and San Francisco 13-14 November and 14-17 November respectively. Details for conducting the same seminar at the CCIW on March 13-14, 1990 were finalized. This workshop/seminar is being co-sponsored by the Pollution Control Association of Ontario, EPA, and WTC. The new EPA Design Manual - Fine Pore Aeration Systems, prepared as part of this project, forms the basis of the seminars.

A meeting of the MOE technical advisory subcommittee set up to determine the current status of flow monitoring and sampling at Ontario WPCP's met to discuss the results of analysis of the data base to date.

WTC personnel reviewed various aspects of instrumentation installation and control system and strategy documentation for the Regional Municipality of Halton.

STATUS REPORT - MARCH 1990

The final meeting of the ASCE/USEPA technical Steering Committee for the fine pore aeration biofouling project on 12 February. This concluded a five-year investigation of biofouling phenomena and strategies for control of biofouling on fine pore aeration systems. A design manual was published and distributed at the 1989 WPCF Annual Conference and is now available through NTIS. G. Speirs contributed a chapter on aeration control to this manual. All final versions of the contractor reports have been received and will be available through the NTIS system. A two-day workshop on Fine Pore Aeration was held at CCIW on March 13-14. The seminar was jointly sponsored by the Pollution Control Association of Ontario, USEPA, and WTC. Although attendance was less than expected, the technical presentations were of very high quality and the feedback very positive.

The first meeting of the Steering Committee for the step feed demonstration project at the Dundas STP was held on Feb. 1. The project objectives and preliminary results were outlined to personnel from the Ontario Ministry of Environment, the Region of Hamilton-Wentworth, McMaster University, and Metropolitan Toronto.

The final report for the City of Windsor's audit of its Little River Treatment Plant was completed by the consultant, reviewed by the steering committee, and submitted to the City of Windsor's Commissioner of Works and the Regional Director of the MOE. The MOE accepted the findings and recommendations of the audit and conveyed the decision to maintain the current nominal capacity rating of the plant to the City.

WTC personnel reviewed the progress to date on the commissioning of the I & C systems at the Regional Municipality of Halton sewage treatment plant projects with Halton Staff.

DIVISION: BIOLOGICAL PROCESSES **PROJECT MGR:** G. SPEIRS

PROJECT NO. 68117 **TEL:** (416) 336-4745

TITLE: OPTIMIZATION OF OPERATIONS AND CONTROL AT THE BANFF TOWNSITE WASTEWATER TREATMENT PLANT

OBJECTIVE:

1) To determine the optimum control strategies for individual unit processes, and the overall treatment train, at Environment Canada's Banff Townsite wastewater treatment plant.

2) To demonstrate to the user community, how state-of-the-art treatment processes and control strategies can be incorporated to achieve the most cost effective wastewater treatment plant design and operation.

RELEVANCE:

The new Banff Townsite Wastewater Treatment Plant represents a state-of-the-art treatment facility incorporating the most recent advances in sludge management and automated computer control. The WTC was extensively involved in the optimization of the treatment plant process design with Reid Crowther & Partners Ltd. - Environment Canada - Parks' design consultant. The plant was designed to incorporate state-of-the- art unit processes with a high degree of automated process control on the liquid train and an integrated sludge management system. The sludge management system incorporates technologies which have been proven in Europe, but are new to North America. The design allows for a high level of operational flexibility over the anticipated design period and ensures value engineering in terms of both capital expenditure and operation and maintenance. The plant construction is scheduled to be completed in the fall of 1989. There is a need to optimize the operation of the facility in terms of overall liquid train treatment efficiency and integrated sludge management. As part of its mandate to investigate and demonstrate cost-efficient solutions to wastewater treatment, this activity represents an opportunity to investigate the performance of specific unit operations and to further demonstrate to the user community, state-of-the-art treatment plant design and operation.

WORK PLAN:

1) Optimize the individual unit processes and, the liquid train as a whole, by identifying optimum automated control strategies to achieve cost-efficient operation and consistently meet plant effluent quality requirements. This will include the effective incorporation of the existing lagoon for flow balancing and storm water control. Particular attention will be paid to energy conservation and the impact of the liquid train operation on, and interaction with, the sludge management system.

2) Investigate fundamental operating considerations for the individual unit operations as part of an overall optimization of the sludge handling train. Specifically, this will address the WRc Inc. sludge thickeners, Autoheated Thermophilic Aerobic Digesters (ATAD), sludge dewatering belt press, and sludge maturation/composting operations.

3) Investigate the application of the CRIQ rotary shoe ring press for improved sludge dewatering performance and associated cost implications.

4) Incorporate and demonstrate advanced process modelling/simulation and control technologies to achieve optimum process control of unit operations, and the plant as a whole, for capital and operational cost savings and enhanced plant performance reliability.

STATUS REPORT - JUNE 1989

A Memorandum of Understanding (MOU) has been established between Environment Canada - Canadian Parks Service and WTC for the provision of day-to-day operation and overall optimization of the Banff WPCP. Aquatrol, a division of Reid Crowther and Partners Limited (RCPL) of Calgary (Banff WPCP design consultant) has been subcontracted by WTC to provide technical services for day-to-day plant operation.

Aquatrol personnel attended an intensive training course on the data acquisition and control system to be used at the WPCP. This will ensure in-house expertise to supplement hardware and software support during the course of the project.

STATUS REPORT - SEPTEMBER 1989

A Memorandum of Understanding (MOU) was drafted between the WTC and representatives from the Town of Banff for the WTC to provide management, operation and maintenance services at the Banff WPCP once it is turned over to the Town. Plant construction continued with the plant expected to be commissioned early in the next quarter.

A full complement of staff were recruited by Aquatrol to operate the facility. They have initiated the development of on-line data base templates and programs for tracking maintenance requirements, scheduling, operating costs and inventory.

A literature review of the ATAD process used at the Banff WPCP was initiated in support of a longer term evaluation program.

STATUS REPORT - DECEMBER 1989

The newly constructed Banff WPCP was commissioned and handed over to Environment Canada - Parks. The WTC and its subcontractor, Aquatrol, a division of Reid Crowther and Partners Limited of Calgary (Banff WPCP design consultant) have accepted responsibility for optimization and day-to-day operation of the facility.

The performance of the plant through a rather extensive commissioning phase has been good. A problem with bulking sludge occurred as a result of excessive sludge age and low loading. The excessive sludge age resulted from having to operate the liquid train for an extended period before the sludge handling facilities were commissioned. Further process upsets due to contractor commissioning activities are not expected.

STATUS REPORT - MARCH 1990

The operation of the newly commissioned Banff sewage treatment facility continued to improve as additional experience with the various unit operations was gained. However, widely fluctuating loading to the plant in combination with problems with on-line control algorithms has led to cyclical problems with sludge settling and sludge inventory control. In spite of this, the plant continues to meet its compliance specifications. The lagoon has been fully integrated and utilized in the plant operation to minimise the impact of these loading variances. Control algorithms have been modified and it has been determined that a number of on-line instruments require more comprehensive in situ calibration to confirm their integrity. As the plant is still under warranty, this work has been delayed because of the need to coordinate and liaise with the contractor/subcontractor/suppliers. It has been identified that, depending upon the outcome of these initiatives, some of the instruments may have to be moved to ensure more reliable, representative information is available to the monitoring and control system.

Discussions have been initiated to identify the activities and approach required to optimize the operation of the individual unit processes. A draft work plan was developed to support further discussions.

Reporting structures and procedures have been established between the Town of Banff, Parks Canada, Alberta Environment, and plant operations staff.

Equipment to dewater and encapsulate raw screenings has been installed to minimize health risks to both plant staff and downstream handlers.

The Memorandum of Understanding established between the WTC and Banff School Board #102 acting on behalf of the Town of Banff prior to the Town's incorporation on January 1, 1990 has been revised to reflect an Agreement between the Minister and the Town of Banff.

DIVISION: **BIOLOGICAL PROCESSES** **PROJECT MGR: D.T. CHAPMAN**

PROJECT NO: 68119 **TEL: (416) 336-4621**

TITLE: **SECONDARY CLARIFIER RESEARCH**

OBJECTIVE:

To plan, coordinate, and monitor international research activities relating to the design and operation of secondary clarifiers.

RELEVANCE:

Secondary clarifiers perform the dual function of removing suspended solids from the overflow to produce a clear effluent, and concentrating solids in the underflow so that an active biomass is maintained in the aeration basin. Inadequate knowledge concerning the fundamentals of clarifier design and operation is a major cause of inconsistent and unacceptable effluent from the activated sludge process.

An interagency agreement between Environment Canada and the U.S. Environmental Protection Agency is in place to support the activities of a group of experts, the Clarifier Research Technical Committee, to develop programs to address high priority research needs in the area of secondary clarification. The Committee is standardizing definitions pertaining to secondary clarifiers, establishing protocols for conducting clarifier research, promoting the use of statistical procedures for designing experiments and building models, establishing peer review procedures, and ensuring that research results are incorporated by consultants into new designs.

WORK PLAN:

1) Four meetings will be held of the five-member steering committee to review committee membership, operation, finances and project activities.

2) The fifteen-member technical committee will meet in Boston in June and in San Francisco in October. Efforts will focus on the completion and testing of a field protocol for evaluating full-scale clarifiers and the publication of a paper comparing clarifier design standards from various countries and U.S. states.

STATUS REPORT - JUNE 1989

The Steering and Technical Committees met in Boston on June 11-12 to review the status of project activities. With respect to the field test protocol, the CRTC committed itself to a 2-year field program, starting January 1, 1990. In the first year, the protocol will be evaluated at secondary clarifiers operated by the L.A. County Sanitation District. These clarifiers are rectangular with sludge removal located at the outlet end of the tank. In the second year, the revised protocol will be used to develop rating curves for the following three types of clarifiers:

- Circular, Centre Feed/Peripheral Removal,
- Circular, Peripheral Feed/Peripheral Removal,
- Rectangular, Front Sludge Removal.

Funding for the first year of the program will come from the IAG between Environment Canada and the U.S. Environmental Protection Agency. For funding for the second year, CRTC members agreed to contact a number of large municipalities with an interest in secondary clarifier design. A comprehensive table with notes comparing design guidelines from various countries, states, and provinces was distributed at the June meeting. The consequences of differences in the guidelines will be quantified by sizing secondary clarifiers for a 10 mgd plant using the various guidelines. The first draft of a position paper on design guidelines will be written and distributed prior to the next CRTC meeting in October.

On the afternoon of June 11, a number of technical presentations were given as part of the CRTC meeting. The speakers and topics were as follows:

a) Karl Kalbskopf, Federal Republic of Germany: ATV Secondary Clarifier Design Procedures & Guidelines,

b) Jack Ellwood, Massachusetts Water Resources Authority: Background to Design of Deer Island Treatment Plant;

c) Al Fermin, Camp, Dresser, McKee, Inc.: Selection & Design of Stacked Clarifiers for Deer Island Plant.

Following the meeting, minutes were written and distributed to CRTC members.

STATUS REPORT - SEPTEMBER 1989

The chair and vice-chair of the CRTC wrote letters to a number of municipalities in the U.S. and Canada seeking assistance in evaluating the performance of alternative clarifier designs. The letter, with support documentation, was mailed to CRTC members who will follow up with the municipalities.

A monthly update was distributed to CRTC members, informing them of plans for the meeting to be held in San Francisco, 19 - 20 October.

STATUS REPORT - DECEMBER 1989

A summary of the status and finances of the project were prepared for discussions with the U.S. EPA. Organization of the Oct. CRTC committee meeting was completed. The meeting was subsequently cancelled because of the Oct. 17 earthquake in San Francisco.

A Steering Committee meeting was held in Chicago on Dec. 3 to review the status of CRTC activities and establish follow-up requirements to obtain funding to support the field test program. A project update was written and distributed to CRTC Technical Committee members.

STATUS REPORT - MARCH 1990

Discussions were held with the CRTC Steering Committee concerning the status of funding for the proposed field test program.

DIVISION: **BIOLOGICAL PROCESSES** **PROJECT MGR:** **R.M. JONES**

PROJECT NO: **68121** **TEL:** **(416) 336-4686**

TITLE: **PROCESS MONITORING AND CONTROL FOR ANAEROBIC TREATMENT SYSTEMS**

OBJECTIVE:

To develop automated monitoring and control strategies for anaerobic reactors to improve process performance and reliability with toxic and inhibitory industrial wastewaters.

RELEVANCE:

Anaerobic biological processes provide an economical alternative for the treatment of concentrated industrial wastewaters. However, many of these effluents contain complex organic and inorganic components which may be inhibitory to the treatment plant microorganisms. Automated monitoring and control systems could help to ensure smooth start-up and efficient and trouble-free treatment plant operation in these applications. Development of monitoring and control strategies is hampered by a lack of understanding of dynamic and steady state process behaviour and by the limited availability of sensors for the on-line measurement of important process variables.

WORK PLAN:

In FY 88/89, dynamic experimentation on the anaerobic fluidized bed pilot plant created a data base for dynamic model assessment. Evaluation of on-line estimation techniques was initiated using simulated data and pilot plant data. A pH control spreadsheet model was developed and used in the design of experiments to investigate operating strategies for the reduction of alkalinity consumption in high rate anaerobic treatment processes.

In FY 89/90, the following tasks will be completed.

1) A multivariable on-line estimation scheme will be developed based on appropriate mechanistic models of the anaerobic process.

2) The estimation scheme will be tested off-line using simulated data and data collected from the anaerobic fluidized bed pilot plant.

3) A loading control strategy based on measured and estimated on-line information will be developed and tested on the anaerobic fluidized bed pilot plant.

4) Experiments will be conducted to confirm pH control strategies which will minimize alkalinity consumption while preventing failure in high rate anaerobic treatment processes.

STATUS REPORT - JUNE 1989

In preparation for a glucose run on the anaerobic fluidized bed, the hydrogen analyzer was modified to measure the high levels of hydrogen expected after a sudden increase in load after spiking the distillery wastewater feed with glucose. Subsequently, a glucose run lasting approximately 18 days was completed on the pilot plant. With the exception of some minor upsets in recycle caused by biological solids accumulating in the reactor recycle lines, the run was completed without problems.

The two population dynamic model was successfully coded and run using the SIMUSOLV package at McMaster. Features in the package which allow plant data to drive the simulation through process inputs and which allow data to be used for parameter estimation were successfully utilized. Parameter estimation on the two population model was conducted using data from the acetic acid run. Verification was attempted using data from the propionic acid run. Inadequacies were revealed in both the parameter estimation method as applied to this problem and in the two population model structure. The estimation problems appeared to be caused by time-varying parameters. As a result, the calibration of the four population model using a Kalman filter to estimate time-varying parameters was initiated.

Construction of a 3 l fluidized bed to run in series with the pilot plant was completed. The reactor was charged with a granular activated carbon media and started up using the distillery wastewater. A two week sampling program was conducted by Microbios Ltd. to monitor growth on the media during a start up period. The reactor was shut down on April 30.

STATUS REPORT - SEPTEMBER 1989

The anaerobic fluidized bed pilot plant continued to operate at the experimental base-line loading of 10 kg COD $m^{-3}d^{-1}$. The plant was shut down temporarily for maintenance in mid-September. During the subsequent start-up of the plant, COD removal and biogas production stopped and loadings were decreased to enable the plant to recover.

Analysis of data from the acetic acid, propionic acid, butyric acid and glucose runs continued. In order to allow estimation of time-varying parameters, and assess the efficacy of a four population model in providing on-line estimates of process variables, a four population model was coupled to an extended Kalman filter state estimation scheme. This required custom software programming, and a number of programming problems in the Kalman filter software had to be resolved before the analysis could proceed. Runs were initiated to assess state observability using simulated data sets based on the same experimental conditions as were used to generate dynamic data on the pilot plant. These runs resulted in a decision to use stochastic state variables which corresponded to individual bacterial concentrations in the model as "fitting" parameters. On-line fitting of these variables could allow the four population model to make more accurate predictions of future performance based on the state of the system at the time of sampling.

STATUS REPORT - DECEMBER 1989

The anaerobic fluidized bed pilot plant continued to operate at reduced loading rates. Loading rate increases were initiated in December in preparation for a verification run.

Analysis of data from the acetic acid, propionic acid, butyric acid and glucose runs continued. During an initial analysis of the experimental data, a Kalman filter was used to assess the effect of intermittent sampling of volatile acids and COD on parameter estimation and subsequent model predictions. The analysis showed that modelling errors were having a significant adverse effect on the stability of the algorithm. For this reason, all fixed parameters in the model were manually refit to the experimental data. Subsequent analysis of the acetic acid run using the Kalman filter showed greatly improved stability. However, a number of significant responses observed experimentally during each of the runs were not predicted by the model. Several alternative kinetic expressions will be evaluated for improving the performance of the model.

STATUS REPORT - MARCH 1990

The anaerobic fluidized bed pilot plant was temporarily shut down due to mechanical problems. Repairs to the recycle line sand trap and replacement of a faulty recycle flow meter are being carried out. An 80 L anaerobic hybrid pilot reactor was leak and flow tested in preparation for pH control experiments.

Analysis of dynamic data from the fluidized bed acetic acid, propionic acid, butyric acid and glucose runs continued. During an initial analysis of the experimental data, a Kalman filter was used to assess the effect of intermittent sampling of volatile acids and COD on parameter estimation and subsequent model predictions. The analysis showed that modelling errors were having a significant adverse effect on the stability of the algorithm. For this reason, all fixed parameters in the model were manually refit to the experimental data. Subsequent analysis of the acetic acid run using the Kalman filter showed greatly improved stability. However, a number of significant responses observed experimentally during each of the runs were not predicted by the model.

Several alternative kinetic expressions have been evaluated for improving the model predictions. A model structure has been selected which has improved the performance of the model while reducing the number of kinetic parameters requiring experimental determination. An extended Kalman filter formulation of the model has been completed and simulation runs have been initiated for determining time-varying, stochastic terms in the model. A parameter sensitivity analysis will be conducted and the Kalman filter will also be used to determine the values of fixed parameters in the model.

DIVISION: **BIOLOGICAL PROCESSES** **PROJECT MGR: E.R. HALL**

PROJECT NO: 68124 **TEL: (416) 336-4715**

TITLE: **ANAEROBIC TREATMENT TECHNOLOGY TRANSFER AND DEMONSTRATION**

OBJECTIVE:

To develop and demonstrate novel high rate anaerobic process technologies for the treatment of concentrated organic wastewaters, and to transfer technical information to potential users of anaerobic treatment systems.

RELEVANCE:

Recent technical developments have made anaerobic processes very attractive for the treatment of large volumes of wastewater containing high concentrations of BOD. To provide the impetus for implementation of anaerobic treatment in the Canada, Environment Canada completed several pilot scale programs which generated data on process design, wastewater treatability and reactor operating strategies. Work will continue on the compilation and distribution of the results from these studies, and organizational support will be provided for technology transfer sessions on related topics. Environment Canada staff will also supply technical support to technology development projects undertaken by industry and other government agencies.

WORK PLAN:

Technical reports and/or papers will be prepared on the following subjects by WTC staff:

1. Evaluation of biological and polymeric additives to decrease the start- up times in anaerobic reactors.
2. Anaerobic Treatment of Industrial Wastewater: Manual of Practice

Technical support provided to the projects indicated below will include proposal review, consultation and advice, and the provision of Scientific Authorities for government-funded contracts. These projects are:

1. Environment Canada - PAPRICAN Study, Spruce Falls Power and Paper Ltd., Kapuskasing, Ont. The final project report will be prepared by PAPRICAN for submission to the project sponsor.

2. Consolidated-Bathurst, Port Alfred Mill, Quebec. A request has been received for the use of the WTC anaerobic hybrid pilot plant for a treatability study to be carried out by Consolidated-Bathurst.

3. Quesnel River Pulp Co., Quesnel, BC. Start-up and troubleshooting of a full scale upflow anaerobic sludge blanket reactor for the treatment of wastewater from alternating TMP and CTMP production.

4. Demonstration of anhybrid technology for anaerobic treatment of landfill leachate by Metropolitan Authority of Halifax, Dartmouth and the County of Halifax. (DRECT)

5. Review of proposals submitted to Bioenergy Development Program, Energy, Mines and Resources Canada, and participation on Strategic Grants Selection Panel, Environmental Toxicology, Natural Sciences and Engineering Research Council, Ottawa.

PROJECT NO. 68124
Page 2

6. Participation on IAWPRC Specialist Group on Anaerobic Digestion.

STATUS REPORT - JUNE 1989

Quesnel River Pulp, Quesnel, B.C.

After reseeding one of the anaerobic reactors, reduced wastewater flows have been resumed to the anaerobic pretreatment stage. To date, the restart has proceeded smoothly. In addition, QRP has initiated planning for several major physical changes in the overall treatment facility.

MacMillan Bloedel, Sturgeon Falls, Ont.

The construction of the full scale Biothane anaerobic treatment was initiated in April.

Consolidated-Bathurst, Port Alfred, Que.

Consolidated-Bathurst has requested the loan of the WTC's transportable anaerobic pilot plant for a study at the Port Alfred mill in Ville de la Baie, Quebec. Engineering staff from the mill visited the WTC on May 10 to review the installation requirements for Environment Canada's anaerobic pilot plant. A formal Loan Agreement was forwarded to Consolidated-Bathurst for approval prior to release of the pilot plant.

CCREM Pulp and Paper Working Group

A report on recent Working Group activities was prepared and forwarded to C. Banwell.

Metro Authority of Halifax-Dartmouth, NS.

Copies of a draft final project report have been received for review at the WTC.

Biological Supplements For Start-up of High Rate Anaerobic Reactors

Preparation of a final project report is ongoing.

STATUS REPORT - SEPTEMBER 1989

Biocatalytic Additives For Start-up of High Rate Anaerobic Reactors

A final version of the project report was completed and a copy was forwarded to Canber Industries Ltd. of Nanaimo, B.C.

STATUS REPORT - DECEMBER 1989

Quesnel River Pulp, Quesnel, B.C.

Several small samples of QRP anaerobic reactor sludge were received at the WTC for QA/QC testing of the activity measurement procedure in use at Quesnel River Pulp. Larger samples were also received for use in ongoing resin and fatty acid desorption studies at the WTC.

Metro Authority of Halifax-Dartmouth, NS.

A copy of the Metro Halifax draft report was received in floppy disk format. The draft is currently under revision at the WTC for the preparation of an Environment Canada Technical Report. A computer file of the operating data for the plant was also received for analysis and incorporation into the project report.

STATUS REPORT - MARCH 1990

Western Pulp Partners, Port Alice, B.C.

E. Hall visited the Port Alice mill on March 26 to review the interim anaerobic pilot study results with mill staff. Most of the mechanical problems have been rectified, and operation with acid condensate feed was satisfactory. After March 12, when caustic extraction filtrate from the bleach plant was added to the pilot plant feed, the performance of the unit deteriorated significantly. The pilot plant operating staff are closely monitoring the system for signs of serious process upset.

Metro Authority of Halifax-Dartmouth, NS.

Additional data has been requested from the Metro Authority to permit the completion of the final DRECT project report.

6th International Symposium on Anaerobic Digestion

At the request of the Organising Committee, E. Hall has agreed to coordinate the activities of the Programme Committee for AD-VI to be held in May 1991 in São Paulo, Brazil.

DIVISION: BIOLOGICAL PROCESSES **PROJECT MGR:** E.R. HALL

PROJECT NO: 68129 **TEL:** (416) 336-4715

TITLE: BIOLOGICAL TREATMENT OF PULP AND PAPER WASTEWATERS

OBJECTIVE:

To develop and demonstrate biological treatment technology for reducing BOD, toxicity and organochlorines in pulp and paper wastewaters.

RELEVANCE:

Recent regulatory initiatives have been undertaken to improve industry compliance with existing pulp and paper effluent regulations and to further reduce the discharge of pollutants from Canadian pulp and paper mills. In order to meet existing and anticipated regulations, additional information is required for successful treatment process design and operation. For example, few data are available on the wastewater characteristics and the treatment options for effluents from the rapidly-expanding chemi-thermomechanical (CTMP) pulping sector. In addition, experimental data are needed to determine how biological treatment processes should be designed and operated to minimize discharges of chlorinated organic compounds and wood extractives.

WORK PLAN:

Chemi-thermomechanical Pulping

A proposal has been prepared for submission to the CCREM pulp and paper subcommittee for a joint federal-provincial program to characterize wastewaters from CTMP mills. Provincial agencies will be invited to provide mill-site sampling and data collection. The WTC will coordinate the program and provide chemical analysis and toxicity testing support services. In addition, a treatability program at the WTC will concentrate on assessing the fate of toxic compounds - such as resin and fatty acids - in aerobic and anaerobic treatment processes.

Bleached Kraft Mill Effluents.

Parallel studies will be undertaken to examine the efficacy of anaerobic, aerobic, and facultative biotreatment systems for the removal of organochlorine compounds from bleached kraft mill effluents. Anaerobic technology will be applied to concentrated and highly toxic, segregated bleach plant wastewaters, and to the more dilute combined mill effluents. Studies on aerobic and facultative treatment will be limited to combined mill effluents to simulate the performance of treatment technologies that are currently in use in the industry. The treatability studies will be coupled to concurrent NWRI projects in which the fate and environmental impacts of residual organochlorines will be assessed.

STATUS REPORT - JUNE 1989

Kraft Mill Bleach Plant Wastewaters

Batch anaerobic and aerobic testing was completed on the bleach plant wastewaters collected from 3 Ontario kraft mills. This testing is designed to compare AOX removal from differing sources of chlorinated material under both anaerobic and aerobic treatment conditions. In addition, a set of long-term fill and draw batch experiments was completed to assess the degree of bio-acclimation achievable during anaerobic treatment of bleach plant wastewaters. A preliminary examination of the results indicated that a slight degree of acclimation occurred during the fill and draw cycles, and that the highest AOX removal occurred in the first cycle. A time course study of an individual batch test was started to examine the chronological relationship between AOX removal, chlorophenolics removal, and methane production. At the end of the assay, the quantity of adsorbed organochlorine material in the biomass will also be measured.

Two continuous flow anhybrid reactors continued to operate with a combination of bleach plant wastewater and methanol as a feed. Methane production has been maintained in both reactors while the fraction of bleach plant wastewater was slowly increased to 50% (vol/vol). The anhybrid reactors are now operating in a high rate mode, at hydraulic retention times of about 30 hours. To date, AOX removal has varied between 40% and 60%. The most highly substituted chlorophenolics appear to be completely removed under these conditions, leading to the production of monochlorophenolics as stable intermediates. Polyurethane (PUR) carrier was added to one of the anhybrid units to improve biomass retention. However, because serious column plugging problems developed rapidly, the carrier was removed from the reactor after only a few days of use. A CSTR reactor design is under development for more effective utilization of the PUR carrier.

The laboratory anaerobic/aerobic treatability units continued to operate at 24°C and SRTs of 5 days, with a combined mill bleached kraft wastewater. AOX removals in the three experimental units have ranged from 35% to 42%. These AOX removal efficiencies are similar to those measured in the high rate anaerobic reactors for the treatment of segregated bleach plant effluents. A short run at 30°C was completed to test the temperature control system. While the experimental design for the study phase of this project is being finalized, work has been started on the off-gas analysis procedures that will be used for closing a mass balance on AOX in the treatability units.

Thermomechanical Pulping Wastewaters

To study the biological and non-biological removal mechanisms for resin acids in anaerobic systems, an intact, inactive anaerobic sludge was required. A sample of active anaerobic sludge was irradiated at McMaster University to inactivate the bacteria, without severely disrupting the sludge structure. Serum bottle testing indicated that the irradiation did not fully inactivate the biomass. Therefore, number of different autoclaving protocols were examined as a substitute inactivation approach. Further serum bottle testing indicated that methanogenic activity was destroyed by autoclaving, but the inactivation of acidogenic activity was not complete. Scanning electron microscopy will be used to determine the physical structure of the sludge after autoclaving.

Following a meeting on June 14, The WTC has reached a preliminary agreement with Millar Western Pulp Ltd. of Whitecourt, Alberta, for the loan of Environment Canada's biological trailer for a pilot study on CTMP wastewater treatment. The pilot program to be undertaken by Millar Western is intended to produce design data for upgrading the existing treatment facility at Whitecourt, and for the design of treatment system for a new hardwood CTMP mill at Meadow Lake, Saskatchewan. The WTC's Biological Treatment Trailer is being retrofitted to meet the Millar Western study requirements. It is anticipated that the trailer will be ready for shipment to Whitecourt by the end of July.

Discussions were held with staff of the Physical/Chemical Processes Division regarding a potential WTC program in membrane technology applications in the pulp and paper sector. Approaches will be made to Swedish companies that are currently working on applications of this type, to determine whether a co-operative program could be arranged.

STATUS REPORT - SEPTEMBER 1989

Kraft Mill Bleach Plant Wastewaters

Mallette Kraft Pulp and Power Inc. of Smooth Rock Falls, Ontario has agreed to provide bleach plant wastewater for use in ongoing WTC research programs. Until this higher concentration bleach plant effluent is received, the anaerobic and aerobic biotreatment studies will remain suspended. In the aerobic treatment study, changes in operating procedures have been made to improve feed rate and SRT control in the two lagoon systems. Temperature control has improved in all three units. However, it is now apparent that computer control will be necessary to obtain the level of control needed to complete the study. A review of preliminary AOX removal data for the aerobic treatment program indicated removal efficiencies of 30% in the activated sludge unit, 40% in the anaerobic/aerobic lagoon, and 40% in the aerobic lagoon.

During the period in which anaerobic treatment experiments have been suspended, preliminary work is being undertaken on the development of a mathematical model of the AOX removal process. In addition, batch studies have been completed to examine the short term adsorption of AOX during the initial stages of anaerobic and aerobic batch biodegradation testing. Under anaerobic conditions, 30% of the initial AOX is removed within four hours of the start of a batch. Under aerobic conditions, approximately 15% of the AOX is removed in the same time period.

Chemi-thermomechanical Pulping Wastewaters

Experimental work on the anaerobic and aerobic biodegradation of resin acids has been completed. In addition, experiments have been completed to define the adsorption kinetics of resin acids on aerobic and anaerobic sludge. The Microtox test unit is also now functional and will be used for future experiments on the desorption of resin acids from biosludge discharged from CTMP wastewater treatment plants.

STATUS REPORT - DECEMBER 1989

Kraft Mill Bleach Plant Wastewaters

Difficulties with bleach plant wastewater sampling and transport from the E.B. Eddy mill in Espanola have been resolved. To preserve the original wastewater characteristics as much as possible, all future shipments of bleach plant wastewaters will be made in plastic containers. Computer-actuated temperature control equipment was installed in the three fume hoods being used for the aerobic treatability testing units. With the establishment of improved temperature control, the first experimental run could be initiated in December. The experimental conditions of this run specified temperatures of 40°C and SRTs or HRTs of 15 days.

A series of experimental runs to compare the performance of complete mix fixed film anaerobic reactors to hybrid anaerobic reactors was completed. Since the hybrid units consistently demonstrated higher AOX and BOD removal efficiencies than the fixed film reactors, the hybrids were selected as the sole option for further study. The hybrids are currently being used for an examination of the effects of hydraulic retention time and level of co-substrate addition on the anaerobic treatability performance with bleach plant wastewaters. This study is using wastewater received from a second Ontario bleached kraft mill. Mallette Kraft Pulp & Power of Smooth Rock Falls, Ontario has agreed to provide chlorination and extraction stage filtrates for the WTC anaerobic treatment study.

Batch experiments have been completed to determine whether contacting C and E stage filtrates with activated carbon improves the anaerobic treatability of the samples. Preliminary results indicate that inhibition was reduced by activated carbon.

Chemi-thermomechanical Pulping Wastewaters

Experimental work on the fate of resin acids in anaerobic and aerobic batch studies was completed. The study results are currently being reviewed prior to the preparation of a project report.

STATUS REPORT - MARCH 1990

Kraft Mill Bleach Plant Wastewaters

The second and third experimental runs were completed in the combined mill effluent treatment study. All three conventional biotreatment systems were operated at 40°C at SRTs of 5 days in run 2, and at 25°C and SRTs of 15 days for run 3. Several equipment alterations were then initiated to permit operation at 10°C for runs 4 and 5.

A series of experimental runs were completed to evaluate the performance of high rate anaerobic reactors treating segregated bleach plant wastewaters at HRTs between 6 and 48 hr. Preliminary data indicate that the mean observed AOX removal efficiency of 65% was relatively insensitive to HRT and to the presence or absence of a readily biodegradable organic co-substrate (methanol).

Batch experiments are continuing to examine the efficacy of modified polyurethane foam carriers for anaerobic treatment of bleach plant wastewater. Similar techniques are also being used to assess AOX removal under facultative conditions with, and without co-substrate addition.

Discussions were held with Zenon Environmental Inc. to develop a joint project to examine the applicability of an anaerobic membrane bioreactor for the treatment of segregated kraft mill bleach plant wastewaters. Zenon has agreed to provide membranes and supporting operational advice. The WTC will supply the anaerobic bioreactor and ancillary equipment. The unit will be operated at the WTC by a Master's level student from McMaster University beginning in May, 1990.

Chemi-thermomechanical Pulping Wastewaters

Experimental work on the fate of resin acids in anaerobic and aerobic batch studies was completed. The study results are currently being reviewed prior to the preparation of a project report.

STATUS REPORT - 1989

REVIEWS

Papers

H. Melcer reviewed 185 abstracts submitted to the Research Symposium of the Annual WPCF Conference to be held in October.

E. Hall reviewed a manuscript submitted for publication in Pulp and Paper Canada.

R. Jones reviewed a paper on anaerobic treatment submitted to Water Research.

ACTIVITIES

E. Hall has agreed to participate on the Program Committee for the 6th International Symposium on Anaerobic Digestion, Rio de Janeiro, 1991.

D. Chapman and G. Speirs met with Dr. Brian Chambers, Water Research Centre (WRc), Swindon, U.K., to discuss research topics of common interest to the WTC and the WRc.

D. Chapman made presentations on step feed control of the activated sludge process and the objectives and activities of the Clarifier Research Technical Committee to the U.S. EPA Technology Transfer Workshop in Ann Arbor, Michigan, June 6-8.

R. Jones participated in the Technical Advances in Biofilms Conference in Nice, France, April 4-8.

R. Jones presented a poster at the 7th Canadian Bioenergy R&D Seminar in Ottawa, April 24-26.

R. Jones gave a presentation on control of anaerobic treatment processes at the Annual Meeting of the Canadian Society of Microbiologists in Laval, Quebec, June 13.

R. Jones met with Dr. Serge Guiot and Dr. Andre Pauss at the NRC Biotechnology Research Institute on June 14 to discuss monitoring and control of anaerobic treatment processes.FILE:-

VISITORS

June 16 - Dr. Kjell Johnsen, Norwegian Pulp and Paper Research Institute, Oslo.

STATUS REPORT - SEPTEMBER 1989

REVIEWS

Proposals

E. Hall reviewed an IRAP proposal on anaerobic treatment submitted by Sleeman Brewery of Guelph, Ontario, and a DRECT proposal on ultrafiltration plus anaerobic treatment prepared by Nutrinor of Chambord, Québec.

Papers

R. Jones reviewed a manuscript submitted for publication in Water Research.

PERSONNEL ACTIVITIES

B. Jank and D. Chapman met with Mike Lyewood and Howard Adams to discuss problems with the secondary clarifiers at the Port Dalhousie WTP.

D. Chapman met with Lorne Yee, Gore and Storrie Ltd., to discuss analysis of tracer data collected by the City of Winnipeg from two of their anaerobic digesters.

D. Chapman served as on the M.Eng. Examining Committee for Mr. D. Nolasco, McMaster University. Mr. Nolasco's thesis was titled "Expert System - Simulation Interaction for Control of the Activated Sludge Process".

E. Hall participated in the fall grant selection meetings of the NSERC Environmental Quality Strategic Grant Panel, in Ottawa, September 18-21.

VISITORS

August 11 - X. A. Fernandes, Water Research Centre, Stevenage, England.

September 26 - Mr. John Roberts, Noranda Inc. Toronto, Ontario.

STATUS REPORT - DECEMBER 1989

REVIEWS

Papers

H. Melcer reviewed 4 papers for the Kyoto IAWPRC Conference.

E. Hall reviewed 1 manuscript for the Canadian Journal of Water Pollution Research and Control, and 8 papers for the upcoming IAWPRC Conference in Kyoto, Japan.

PERSONNEL ACTIVITIES

E. Hall prepared a presentation for a Continuing Education Course on Anaerobic Treatment of Industrial Wastewater at the University of Wisconsin-Milwaukee on December 4 & 5. Due to a conflict with the Alberta-Pacific Environmental Assessment Board hearings, the presentation was made by R. Jones.

D. Chapman attended the short course "Time Series Modelling for Water Resources and Environmental Engineers" held at the University of Western Ontario from Dec. 11-15, 1989.

VISITORS

December 13	Mr. Joe Dorica, Paprican, Pointe Claire, Québec.

STATUS REPORT - MARCH 1990

REVIEWS

Proposals

E. Hall reviewed a proposal to Fonds FCAR, Sainte-Foy, Québec, entitled "Detoxification d'un effluent d'une usine de pâte thermomécanique par traitement anaerobie".

PERSONAL ACTIVITIES

E. Hall and H. Melcer visited the Department of Civil Engineering, University of British Columbia on March 23.

VISITORS

March 14	Dr. J. Scharer, University of Waterloo.

DIVISION: RESIDUE MANAGEMENT **PROJECT MGR:** T.W. CONSTABLE

PROJECT NO: 68334 **TEL:** (416) 336-4716

TITLE: TOXICS IDENTIFICATION AND MOBILITY IN SLUDGES

OBJECTIVE:

1) Continue development of a data base on toxics accumulation and mobility in sludges.
2) Provide technical and analytical support to other C&P groups.

RELEVANCE:

Waste disposal sites have been identified as major contributors of toxics entering the ecosystem. Leaching tests can be used as indicators of the potential leachability of a waste and for comparisons among different waste types and forms.

WORK PLAN:

1) Continue development of the data base using bench-scale leaching tests on a variety of wastes.
2) Provide technical and analytical support to other C&P groups on an as required basis.

STATUS REPORT - JUNE 1989

No activity.

STATUS REPORT - SEPTEMBER 1989

No activity.

STATUS REPORT - DECEMBER 1989

No activity.

STATUS REPORT - MARCH 1990

No activity.

DIVISION: RESIDUE MANAGEMENT **PROJECT MGR:** H.W. CAMPBELL

PROJECT NO: 68335 **TEL:** (416) 336-4717

TITLE: ENERGY CONSERVATION: INTEGRATED SLUDGE MANAGEMENT SYSTEMS

OBJECTIVE:

1) To optimize energy usage at integrated sludge management facilities.
2) To develop a data base on sludge treatment facilities in Canada.

RELEVANCE:

Energy audits conducted on the sludge train have indicated that very significant energy savings can be expected through optimization of the sludge management train. The principle sludge unit operations can all be energy intensive and their correct coupling and optimization will effect significant energy and capital cost savings. Through optimization of the sludge train, it is anticipated that national annual energy savings of $8 to 10 million could be realized.

WORK PLAN

1) Develop conceptual approaches for optimization of energy usage at integrated sludge management facilities.
2) Initiate a contract and act as scientific authority.
3) Integrate information on sludge facilities at Canadian sewage treatment plants into the existing MUNDAT data base.

STATUS REPORT - JUNE 1989

No activity.

STATUS REPORT - SEPTEMBER 1989

No activity.

STATUS REPORT - DECEMBER 1989

No activity.

STATUS REPORT - MARCH 1990

No activity.

DIVISION: RESIDUE MANAGEMENT **PROJECT MGR:** H.W. CAMPBELL

PROJECT NO: 66336 **TEL:** (416) 336-4717

TITLE: PROCESS CONTROL - SLUDGE CONDITIONING/DEWATERING

OBJECTIVE:

To determine the effect of mixing intensity on polymer utilization with belt filter presses, using the WTC sludge conditioning controller and an Optifloc mixer developed by WRC.

RELEVANCE:

The sludge conditioning controller has been shown to be capable of optimizing polymer dosage for a conventional belt press. Studies in the UK have indicated that most polymer addition systems do not provide sufficient mixing intensity between sludge and polymer resulting in under-utilization of the polymer. The Optifloc mixer developed by WRC used in conjunction with the WTC sludge conditioning controller could result in significant additional polymer savings.

WORK PLAN:

1) Complete evaluation of the interaction between the OPTIFLOC and the sludge conditioning controller.
2) Determine applicability of the OPTIFLOC for use with the rotary press.
3) Identify site and initiate demonstration phase.

STATUS REPORT - JUNE 1989

In April problems with the SCC head were encountered and the head and sensor were replaced. Subsequent work showed that the SCC could operate in conjunction with the OPTIFLOC. In several runs with the OPTIFLOC operational, the polymer dosage was arbitrarily changed and the SCC restored the dosage to the appropriate level in as low as four sampling periods. However, inconsistencies in the SCC readings continued to persist. Additional work is planned to determine the cause of these inconsistencies.

The OPTIFLOC was removed from the belt press at the WTC and installed on the rotary press at Granby. Start-up of the rotary press is scheduled for August.

STATUS REPORT - SEPTEMBER 1989

Data was collected from the SCC's at Guelph on an intermittent basis. Some of the preliminary data appeared to contain inconsistencies similar to those observed at the WTC. However, since no information was available on solids concentrations, the reasons for the inconsistencies were difficult to determine. Modifications were made to the SCC's at Guelph and subsequent data collected. This data is currently being analyzed.

PROJECT NO. 68336
Page 2

STATUS REPORT - DECEMBER 1989

The data from Guelph was discussed with Zenon and they are currently evaluating it. Activity with the OPTIFLOC is discussed under Project 41.

STATUS REPORT - MARCH 1990

No further development work was conducted with the OPTIFLOC although it was used as a conditioning system for the rotary press in Granby.

DIVISION: **RESIDUE MANAGEMENT** **PROJECT MGR: M.D. WEBBER**

PROJECT NO: 68337 **TEL: (416) 336-4519**

TITLE: **TECHNOLOGY DEVELOPMENT: LAND APPLICATION OF MUNICIPAL SLUDGE**

OBJECTIVE:

To develop and demonstrate technology with a view to promoting land application of sludge as an environmentally sound management practice.

RELEVANCE:

Roughly 40% of Canada's sludge is land applied and this utilization option supplies much needed nutrients and humus to agricultural soil. Satisfactory guidelines have been developed to make effective use of sludge nutrients and to manage the risks presented by pathogens and heavy metals. However, there are no guidelines to manage risks associated with organic contaminants contained in sludge. Continued technology development is required to obtain information on which to base organic contaminant guidelines for sludge use in agriculture.

WORK PLAN:

1) To conduct a comprehensive review of information concerning organic contaminants in sludge and their fate in agricultural soil.
2) Analyze soil samples taken from sites in Ontario which have received large applications of sludge for extended periods of time and from control sites, to determine whether the sludge has resulted in build-up of organic contaminants in soil.
3) To conduct laboratory and greenhouse studies on the fate of organic contaminants in municipal sludge applied to agricultural land.

STATUS REPORT - JUNE 1989

A draft report of results to date for the study "Fate of Organic Contaminants in Municipal Sludge Applied to Land" is nearing completion.

M. Webber attended meetings, April 3 and May 29, of the Research and Standards Subcommittee of the Ontario Sludge and Waste Committee to discuss joint federal/provincial funding of organic contaminants research in relation to land application of sludge in Ontario. No agreement was reached.

During studies of the persistence of volatile organic contaminants in sludge treated soils it was observed that recoveries of 14C-labelled trichloroethylene measured by gas chromatographic and radiochemical techniques were approximately 40 and 95%, respectively. Despite considerable effort, this large discrepancy between the two methods of measurement has not been resolved.

Six soils representing wide ranges of texture and soil organic matter content have been collected. They will be used in future laboratory studies of the persistence of ten volatile organic contaminants in sludge treated soils and in greenhouse studies.

Two short papers entitled "Persistence of volatile organic contaminants (VOC) in sludge treated soils" by M.D. Webber and J.D. Goodin and "Greenhouse studies with 14C-labelled organic contaminants" by J.D. Goodin and M.D. Webber were prepared for poster presentations to an international workshop on Alternative Uses for Sewage Sludge to be held in York, UK, 5-7 September.

STATUS REPORT - SEPTEMBER 1989

Preliminary laboratory incubation studies using the method developed with 1,1-dichloroethane, trichloroethylene, toluene and ethylbenzene have been completed with a mixture of ten volatile organic contaminants added to three sludge treated soils. The ten contaminants are: chloroform, benzene, o-xylene, 4-ethyltoluene, 1,4-dichlorobenzene, 1,3-dichlorobenzene, 1,3-diethylbenzene, toluene, ethylbenzene, 1,1-dichloroethane and 1,2,4-trichloroethylene. The method proved satisfactory for all of the compounds and large amounts of each were recovered during aeration at 22°C for only four hours. Twelve-day incubation studies for systems involving the ten compounds and six sludge treated soils representing a range of clay and organic matter contents are in progress.

A microcosm study with sludge treated Caledon loamy sand, Conestoga loam and Lincoln clay soils with four levels of addition of 14C-labelled anthracene has been initiated. 14C occurring as volatile organic, CO^2 and in ryegrass plant material will be monitored during the experiment. To date, the experiment has run for eight weeks and small amounts of $14CO^2$ indicate some biodegradation of the anthracene in all of the soils. At the conclusion of the experiment, soil will be removed from the microcosms and analyzed to measure residual anthracene and to determine whether it has moved below the 0-15 cm zone of incorporation.

A poster presentation entitled "Greenhouse studies with 14C-labelled organic contaminants" by J.D. Goodin and M.D. Webber was displayed in the foyer of the CCIW main building during the week of August 28 to September 1.

Two poster presentations entitled "Persistence of volatile organic contaminants (VOC) in sludge treated soils" by M.D. Webber and J.D. Goodin and "Greenhouse studies with 14C-labelled organic contaminants" by J.D. Goodin and M.D. Webber were made to an international workshop on Alternative Uses for Sewage Sludge in York, UK, September 5-7, 1989.

STATUS REPORT - DECEMBER 1989

A draft report of results to date for the study "Fate of Organic Contaminants in Municipal Sludge Applied to Land" has been completed.

Twelve-day incubation studies with ten volatile organic contaminants (VOC) and seven sludge treated soils representing a range of clay and organic matter contents have been conducted . The ten VOC are; chloroform, benzene, o-xylene, 4-ethyltoluene, 1,4-dichlorobenzene, 1,3-dichlorobenzene, 1,3-diethylbenzene, toluene, ethylbenzene, 1,1-dichloroethane and 1,2,4-trichloroethylene. The data indicates analytical problems, particularly for the chlorinated compounds, and probably it will be necessary to repeat some of these studies.

A preliminary laboratory incubation study in which anthracene, chrysene, hexachlorobutadiene, hexachlorobenzene, and 2,2',5,5'-tetrachlorobiphenyl were incubated with sludge treated soil for 14 days has been completed. Measurements of residuals in the soil were highly reproducible and indicate some degradation of anthracene but no degradation of chrysene, hexachlorobenzene, and 2,2',5,5'-tetrachlorobiphenyl. Hexachlorobutadiene disappeared rapidly from the soil probably by volatilization. A long-term study with these compounds, except for hexachlorobutadiene, will be undertaken in the near future.

A microcosm study with sludge treated Caledon loamy sand, Conestoga loam and Lincoln clay soils with four levels of addition of 14C-labelled anthracene has been completed. Results indicated approximately 20% degradation of the anthracene in Caledon soil but less than 5% degradation in other soils. Plant (ryegrass and soybean) samples were harvested and will be analyzed for 14C to determine whether there has been uptake of anthracene. Soil samples will by analyzed to measure residual anthracene and to determine whether it has leached below the 0-15 cm zone of incorporation.

STATUS REPORT - MARCH 1990

Studies of the persistence of ten VOC's; chloroform, toluene, 1,4-dichlorobenzene, benzene, ethylbenzene, 1,3-diethylbenzene, o-xylene, 1,1-dichloroethane, 3-ethyltoluene and trichloroethylene in sludge treated soils have been completed. A preliminary consideration of the data indicates that most compounds volatilized and disappeared rapidly from the soils. However, some were retained and the degree of retention appeared to be related to the organic matter content of the soils. A thorough review and interpretation of the results is pending.

A microcosm study involving 14C-labelled anthracene, three soils (Caledon loamy sand, Conestoga loam and Lincoln clay) and two crops (ryegrass and soybeans) was conducted. Plant and soil analyses have not been completed, however, initial results indicate that there was no significant uptake of 14C by either crop. Bioconcentration factors (dpm 14C per g dw of grass / initial dpm 14C per g dw of soil) calculated for ryegrass were <0.05. Approximately 25% of the anthracene added to Caledon soil mineralized within 19 weeks, but only about 5% of that added to the Conestoga and Lincoln soils mineralized within the same period. A mass balance of 14C added to Caledon soil indicated that 94% was accounted for in the soil and as 14CO_2. Laboratory incubation studies conducted following completion of the microcosm experiment, indicated that disturbance increased anthracene degradation in the Conestoga and Lincoln soils but not in the Caledon soil. Adding nutrients and readily degradable organic matter did not affect anthracene degradation rate in any of the soils.

M. Webber discussed organic contaminant research with Dr. G.A. O'Connor at New Mexico State University, Las Cruces, New Mexico, January 12 and participated in the Western Regional Research Project W-170 meeting, Las Vegas, Nevada, January 15-17. A report of WTC research activities concerning the persistence and plant uptake of organic contaminants in sludge treated soils was presented to the meeting.

A poster presentation entitled "Greenhouse studies with 14C-labelled anthracene" by J.D. Goodin and M.D. Webber was presented at the 25th Symposium on Water Pollution Research (CAWPRC), Burlington, Feb 15.

M. Webber attended the 1990, EPA Municipal Wastewater Technology Forum, Orlando Florida, March 20-22 where he presented a paper entitled "Municipal sludge, organic contaminants and agricultural utilization".

DIVISION: RESIDUE MANAGEMENT **PROJECT MGR:** M.D. WEBBER

PROJECT NO: 68341 **TEL:** (416) 336-4519

TITLE: TECHNICAL SUPPORT: QUEBEC REGION

OBJECTIVE:

To provide technical support to C&P Quebec Region and the MINVEQ with respect to Sludge Treatment, Utilization and Disposal.

RELEVANCE:

MINVEQ has embarked on an ambitious water pollution control program and intends spending in excess of $2 billion to install pollution abatement facilities. The Canada-Quebec agreement provides the vehicle for technology transfer.

WORK PLAN:

Provide support as required under the Canada-Quebec Agreement. Specific items identified to date include:

1) Provide technical support to Les Industries Fournier under the IRAP program to develop the rotary press for municipal sludge dewatering.
2) Provide technical support in relation to sludge utilization research and demonstration projects.
3) Support the Thetford Mines program to restore asbestos mine tailings via sludge application.

STATUS REPORT - JUNE 1989

M. Webber reviewed a draft report entitled "Recherche sur les effets d'entreposage des boues d'épuration et comparaison des valuers fertilisantes des boues liquides versus les boues déshydratées" for Environnement Canada, Centre St-Laurent.

The rotary press was installed in Granby in late June. The OPTIFLOC was also installed in Granby. Calibration and debugging of the system is underway.

STATUS REPORT - SEPTEMBER 1989

A site inspection and progress review meeting was held in Granby on July 4. Wet testing was initiated in August and problems were encountered with tolerances on the ring. These were subsequently corrected.

P. Crescuolo spent September 25-29 at the Granby site and H. Campbell attended a meeting on-site on September 28. Preliminary runs on the press dewatered biological sludge from 4% solids to 25% solids but at a very low throughput rate. Problems are being encountered with the screens and with the cake discharge chute. Modifications are being tried to correct the situation.

The method of calibrating the various pumps does not appear to be adequate and the current operational practice tends to result in fluctuating flows and pressures.

STATUS REPORT - DECEMBER 1989

Modifications to the press continued to be implemented. P. Crescuolo spent October 23-27 and November 20-24 at the Granby site. A progress review meeting was held in Montreal on November 2. Operation of the press continued to be intermittent due to mechanical problems and non-representative sludge. Some runs were completed with newsprint amended sludge in order to determine deflection of the shaft. The OPTIFLOC mixer was tried and appeared to generate a superior floc to that produced by the flocculator. In December the press was operated with the new screens (0.008" holes) and spring loaded wipers. Operation appeared to be stable although throughput rates were still very low. Work continued on the evaluation of polymers and the method of conditioning. A progress review meeting is scheduled for mid-January.

M. Webber participated in a planning meeting for a "Colloque sur la valorisation des boues de stations d'epuration municipales" to be held in Hull, Quebec, September 18, 19, 1990. The Planning meeting was held in Quebec City, November 7.

STATUS REPORT - MARCH 1990

A progress review meeting was held in Granby on January 22. It was agreed that the Granby sludge was not suitable for the development of the rotary press due to high levels of oil and grease in the sludge and excessive amounts of soluble BOD in the influent. A proposal to test five additional sludges including raw and digested sludge from CRO in Gatineau was approved. Work continued on pressing MUC sludge in order to obtain the necessary data for Fournier to bid on the MUC contract.

DIVISION: **RESIDUE MANAGEMENT** **PROJECT MGR: H.W. CAMPBELL**

PROJECT NO: 68342 **TEL: (416) 336-4717**

TITLE: **TECHNICAL SUPPORT: HAZARDOUS WASTE MANAGEMENT**

OBJECTIVE:

Provide technical advice and support to IPB, Regions and Provincial agencies with respect to technology for hazardous waste management.

RELEVANCE:

Management of hazardous wastes in an environmentally sound manner is mandatory. Numerous site specific solutions are being sought, as are criteria for establishing acceptable technology for integrated facilities.

WORK PLAN:

1) Continue support to AR regarding remedial action at SYSCO.
2) Continue support to OWMC and MOE.
3) Interact with WMD of IPB regarding waste management technologies.
4) Participate as a member of the Working Group on Transportation of Dangerous Goods and Hazardous Wastes.

STATUS REPORT - JUNE 1989

Working Group on TDG Hazardous Wastes

T. Constable met with Canviro staff several times to discuss revisions to the report on the Canadian Extraction Procedure (CEP) validation study, and statistical analysis of the data. He participated in a meeting of the Working Group on TDG Hazardous Wastes, which was held in Ottawa on June 7-8.

STATUS REPORT - SEPTEMBER 1989

Working Group on TDG Hazardous Wastes

T. Constable, Luke Trip of IPB and Duncan MacLeod of the Systems & Informatics Directorate met with Canviro Consultants on September 6 to discuss the Canadian Extraction Procedure (CEP) validation study report and statistical analysis of the data.

T. Constable attended a meeting of the Working Group on TDG Hazardous Wastes in Montreal on September 24-25.

STATUS REPORT - DECEMBER 1989

Working Group on TDG Hazardous Wastes

A flow chart comparing the methodologies of the two proposed Canadian Extraction Procedures (CEPS's), and a table comparing their merits and shortcomings, were prepared. These information sheets were sent to the laboratories that had participated in the CEP validation study for review prior to their distribution to the Working Group on TDG Hazardous Wastes.

STATUS REPORT - MARCH 1990

T. Constable presented four papers at the Contaminated Land Assessment and Remediation Seminar in Vancouver on Jan. 23. The papers were "General Overview of Waste Characterization and Solidification/Stabilization Program", "Proposed Evaluation Protocol for Stabilized/Solidified Wastes", "An Introduction to the Use of the AERIS Model in Site Decommissioning" and "In-Situ Degradation of PCP Contaminated Soil".

Working Group on TDG Hazardous Wastes

T. Constable attended a meeting of the TDG Hazardous Wastes Working Group in Vancouver, Jan. 29 - 31.

DIVISION: **RESIDUE MANAGEMENT** **PROJECT MGR: T.W. CONSTABLE**

PROJECT NO: 68343 **TEL: (416) 336-4716**

TITLE: **TEST METHODS FOR SOLIDIFIED WASTE CHARACTERIZATION**

OBJECTIVE:

1) To develop, validate and standardize test methods for the characterization of solidified wastes.
2) Development of a solidified waste characteristics data base for use in establishing performance criteria.
3) To promote acceptance of tests developed by standardization committees.

RELEVANCE:

Solidification technologies have the potential of reducing leaching of hazardous constituents from wastes disposed on land. This project will help to determine the best available technology and establish performance criteria.

WORK PLAN:

1) Investigate methods to be used for QA/QC in a solidification plant to predict the physical and leaching properties of the cured solidified wastes (in co-operation with the OWMC).
2) Develop an accelerated extraction procedure based on sonic agitation.
3) Pursue standardization of the WTC Test Methods with ASTM Committee D34 on Waste Disposal.

STATUS REPORT - JUNE 1989

The final version of the report for the cooperative program was sent to Ottawa at the end of April for publication.

Development of Accelerated Extraction Test

The scheduled testing of the four selected residues is 50% completed. It has been necessary to repeat several of the procedures due to temperature control difficulties. The extractions have been conducted in a controlled atmosphere (22°C), however extract temperatures are effected by heat of neutralization.

STATUS REPORT - SEPTEMBER 1989

The final version of the report for the cooperative programs is in the hands of the publishers in Ottawa for publication.

Development of Accelerated Extraction Test

The scheduled testing of the four selected residues is 90% percent completed.

It was necessary to repeat several of the accelerated procedures due to inconsistency in the level of power being delivered to test replicates. It was initially planned that three replicates of each extraction would be performed. As there are two ultrasonic probes used for accelerated extraction, it was necessary that one replicate of each waste product be performed in conjunction with a dissimilar waste product. An ultrasonic cavitation device emits varying amounts of energy depending on the viscosity and energy handling characteristics of its environment. Although the various wastes were all reduced to similar particle size, the environments which they created within the extraction fluid were not identical. To resolve this problem, extra replicates were initiated such that the materials subjected to ultrasonic agitation were identical for each ultrasonic probe.

STATUS REPORT - DECEMBER 1989

Cooperative Program

The final version of the report for the cooperative program is in the process of publication. Several portions of the report required clarification, and Julia Stegemann returned from Germany for the first two weeks of December to finalize the report.

Development of Accelerated Extraction Test

All of the extraction tests have been completed and the leachates have been analyzed.

There were problems with the ultrasonic agitation method which had not been addressed in the original experimental design.

It was found that ultrasonic agitation is very hard on the tip of the ultrasonic horn. The tip becomes pitted with use and must be ground back to the original geometry after every hour to hour and a half of use.

Also, the frequency generator which provided the high voltage pulses of energy at 20kHz adjusted for varying load conditions. Consequently, the equipment was affected by the temperature (which was controlled) and the viscosity (which could not be controlled) of the processed material. The equipment increased or decreased the power output to the probe automatically when it sensed an impedance change. In the particular apparatus used there were two probes operating as slave and master. The characteristics of the material processed by the master dictated the processing of both probes and, hence, caused problems whenever dissimilar materials were used concurrently. Due to this mechanical characteristic of the apparatus, the processing of triplicates produced erratic results and it was necessary to repeat many of the accelerated tests in quadruplicate.

A report has been initiated by Rob Caldwell. Julia Stegemann is currently performing the statistical analysis of the data.

STATUS REPORT - MARCH 1990

Cooperative Program

The final version of the report for the cooperative program is in the process of publication. Several portions of the report required clarification and have been reworked.

Development of Accelerated Extraction Test

A report was prepared by Rob Caldwell and Julia Stegemann. The report is now being reviewed in-house to determine whether the results justify further development of the testing method.

DIVISION: RESIDUE MANAGEMENT **PROJECT MGR:** T.W. CONSTABLE

PROJECT NO: 68344 **TEL:** (416) 336-4716

TITLE: TECHNOLOGY TRANSFER: WASTE SOLIDIFICATION

OBJECTIVE:

1) To promote the use of stabilization/solidification as a final treatment process for the disposal of hazardous wastes.
2) To promote the use of proper laboratory testing methods to evaluate solidified wastes.

RELEVANCE:

The expertise gained at the WTC regarding the mechanisms of contaminant containment and leaching and in the evaluation of solidified wastes must be transferred to ensure optimal use of the technology for the control of hazardous wastes.

WORK PLAN:

1) Continued development of a literature data base on leachability of solidified wastes.
2) Finalization of "Guide for the estimation of waste leachability" and preparation of a review of waste form properties.
3) Participate in the organization of symposium/workshops and respond to requests from users of the technology.
4) Promote the use of solidified waste assessment protocol.

STATUS REPORT - JUNE 1989

The leaching guide, entitled "Compendium of Waste Leaching Tests", was approved internally and the final draft sent to Ottawa to be published as an Environment Canada report.

A third draft of the protocol, entitled "Proposed Evaluation Protocol for Stabilized/Solidified Wastes" is presently in preparation.

STATUS REPORT - SEPTEMBER 1989

The final draft of the leaching guide, entitled "Compendium of Waste Leaching Tests", is currently in Ottawa being prepared for publication as an Environment Canada report.

A third draft of the protocol, entitled "Proposed Evaluation Protocol for Stabilized/Solidified Wastes", was completed and has been distributed for peer review.

STATUS REPORT - DECEMBER 1989

The final draft of the leaching guide, entitled "Compendium of Waste Leaching Tests", is currently in Ottawa being prepared for publication as an Environment Canada Report.

A third draft of the protocol, entitled "Proposed Evaluation Protocol for Stabilized/Solidified Wastes" was completed and has been distributed for peer review. Comments from the MOE, US EPA and ASTM committee D34 have not yet been received.

STATUS REPORT - MARCH 1990

The final draft of the leaching guide, entitled "Compendium of Waste Leaching Tests", is currently in Ottawa being prepared for publication as an Environment Canada report.

Further work on the "Projected Evaluation Protocol for Stabilized/Solidified Wastes" has been put on hold pending receipt of comments from MOE.

DIVISION: **RESIDUE MANAGEMENT** **PROJECT MGR:** **T.W. CONSTABLE**
PROJECT NO: **68345** **TEL:** **(416) 336-4716**
TITLE: **ASSESSMENT OF SOLIDIFICATION TECHNOLOGY**

OBJECTIVE:

1) To evaluate the applicability of existing processes to new waste streams.
2) To assess new solidification processes from a mechanistic point of view.
3) To use a modelling approach to predict leaching of solidified wastes in a field environment.

RELEVANCE:

Solidification is a relatively new technology. The WTC is promoting the use of an assessment protocol based on measurement of physical, engineering and chemical properties.

WORK PLAN:

1) Co-operate with users of the technology to assess the suitability of commercial processes and various disposal scenarios.
2) Evaluate the potential of vitrification to immobilize residues allowing for reuse of the waste.

STATUS REPORT - JUNE 1989

Two proposals for FY 1989/90 experimentation were submitted to Zenon Environmental Inc. (OWMC consultant) for their consideration:

- Engineering Properties Testing of Solidified Residues
- Column Test Preparation for the Evaluation of Salt Migration Through a Clay Bed

OWMC Project A - Stability of Sulphide Precipitates

The draft report is currently being reviewed by OWMC and their consultants.

OWMC Project B - Column Test Evaluation of Salt Leaching

The draft report (FY 1988/89) is currently being reviewed by OWMC and their consultants.

OWMC Project C - Optimization of Organic Contaminant Containment

A report is in process, however, the analytical results of several extracts have yet to be received from the laboratory. Completion of a draft report is expected for July.

RW Project - Evaluation of Solidification as a Long-term Solution for On-site Closure of Effluent Lagoons

Of the twenty batches prepared during Phase I of the experimental program, one formulation was selected for continued testing based on physical integrity and contaminant leachability. A large batch of the effluent lagoon sludge was solidified using this formulation and then allowed to cure for 28 days at room temperature. Upon the completion of curing the on-going Phase II extended experimental program was initiated.

STATUS REPORT - SEPTEMBER 1989

A study entitled "Column Test Preparation for the Evaluation of Salt Migration through a Clay Bed" will be conducted at WTC as a result of a proposal submitted to Zenon Environmental Inc. (OWMC consultant). The study involves the development of a suitable stabilization/solidification formulation for the treatment of salt/ash created through the incineration of organic wastes and column test studies to monitor the effectiveness of the S/S process. The study is a continuation of work undertaken during FY 88/89 (Column Test Evaluation of Salt Leaching).

OWMC Project A - Stability of Sulphide Precipitates

The final report was prepared and delivered to OWMC.

OWMC Project B - Column Test Evaluation of Salt Leaching

The final report was prepared and delivered to OWMC.

OWMC Project C - Optimization of Organic Contaminant Containment

The report is in progress, however, the last analytical results were received in September and a draft report will not be completed until the middle of October.

RW Project - Evaluation of Solidification as a Long-term Solution for On-site Closure of Effluent Lagoons

The extended testing of the selected formulation has been completed, with the exception of the hydraulic conductivity measurement. The data reduction has been completed and a draft report will be completed by the second week of October. A meeting was held September 27, 1989 at WTC which was attended by Herb Campbell and Rob Caldwell of WTC, Dave Lepore of Robertson-Whitehouse and George Nishikawa, a Robertson-Whitehouse consultant, to discuss the status of the project. Another meeting will be held during the week of October 23, after review of the draft report.

STATUS REPORT - DECEMBER 1989

Zenon Project: Salt Migration Through a Clay Bed

A meeting took place on October 10, 1989 at WTC which was attended by R.J. Caldwell and H.W. Campbell of WTC, Pierre Côté of Zenon, and Chih Chao of OWMC. At this time the results of WTC's FY 1989/90 testing were reviewed. These results included:

- the LX values (-log of the apparent coefficient of diffusion) for chloride ion within the 14 matrices prepared at WTC
- the unconfined compressive strength (UCS) measurements of each of the 14 matrices, and
- a cost analysis for each matrix based on projected additive costs and space requirements within the landfill per tonne of ash treated

Also, at this time a formulation was selected (WTC formulation #10) based on the results, and OWMC revealed that their process will no longer generate an ash with such a high chloride content. WTC was asked to rework their experimental program in order to reflect these process changes.

A revised OWMC experimental program was prepared during the first week of November. A meeting was held on November 28, 1989 at Zenon which was attended by Pierre Côté and John Bansci of Zenon, and Rob Caldwell of WTC. At this time a revised phys-chem pretreatment procedure was developed for the ash. The new method will decrease the chloride concentration of the sludge substantially and closely parallel the phys-chem pretreatment process developed by Zenon for the proposed OWMC facility.

OWMC Project: Optimization of Organic Contaminant in Solidified Wastes

A draft report was sent to OWMC during the third week of October and is being reviewed by OWMC and their consultants. Upon receipt of their comments, a final report will be prepared.

RW Project: Evaluation of Stabilization/Solidification as a Long-term Solution for On-Site Closure of Effluent Lagoons

A draft report was sent to Robertson-Whitehouse for review during the second week of October.

A meeting was held November 10, 1989, at WTC with George Nishikawa of George Nishikawa and Associates (Robertson-Whitehouse's consultant), and Herb Campbell and Rob Caldwell of WTC in attendance. The draft report "Evaluation of Stabilization/Solidification as a Long-Term Solution for On-Site Closure of Effluent Lagoons" was discussed and finalized. The final version of the report was completed and sent to George Nishikawa on November 23, 1989.

STATUS REPORT - MARCH 1990

Zenon Project: Salt Migration Through a Clay Bed

OWMC has revised the phys-chem treatment procedure for treatment of fly ash from their proposed hazardous waste incinerator. The new procedure will substantially decrease the chloride concentration of ash/sludge being treated by solidification. However, there is still interest in the prospect of using a high chloride ash/sludge to evaluate the effect of salinity on the self sealing/self healing (SS/SH) barrier (project 59). In aid of this, a sample of high Cl ash/sludge, produced using the hydroxide/sulphide pretreatment method developed during FY 88/89, was delivered during the first week of January to Jim Kramer at McMaster University for use in SS/SH barrier development. Samples of other materials required for solidification of the residue were also supplied, along with a sample of unweathered LF9C clay. A meeting is scheduled at WTC for the 25th of April to discuss McMaster's progress and a formulation for the SS/SH barrier is expected from McMaster the first week of May, at which time solidification of ash residues within the columns will take place.

Solidified test batches of the low chloride ash/sludge were prepared, cured under accelerated conditions, then evaluated using 5 day ANSI/ANS 16.1 (chloride diffusion) and physical integrity testing. Based on the results of these tests, a formulation was chosen for the preparation of the columns. Further samples of the high and low Cl ash, solidified using the selected formulations, were prepared for more extensive testing. Further testing was required to ensure that the phys-chem pretreatment and solidification operations being evaluated would provide suitable levels of containment for other contaminants of interest which were not targeted in preliminary testing.

The final milling and machining of individual column segments has been completed and extrusion of LF9C clay from the shelby tubes, provided by OWMC, into the columns took place on February 11th, 1990. Due to the quantity of small stones found in the clay, some problems were encountered. However, 8 columns were extruded with lengths ranging from 20 to 30 cm. The ends of the columns were capped and they were placed in controlled atmosphere to await solidification.

The first three of eight columns were prepared March 20th, 1990 by solidification of the low Cl ash/sludge directly on top of the undisturbed clay within columns 1, 2 and 3. A syphon system was attached to control the hydraulic gradient through the sample. Distilled water, to which sodium azide was added (500 g/mL), was used to impose the gradient.

OWMC Project: Optimization of Organic Contaminant Containment in Solidified Wastes

A draft report was sent to OWMC during the third week of October, 1989. We are awaiting the comments of OWMC and their consultants on the draft report. Upon receipt of these comments a final report will be prepared.

DIVISION: **RESIDUE MANAGEMENT** **PROJECT MGR: M.D. WEBBER**

PROJECT NO: 68346 **TEL: (416) 336-4519**

TITLE: **TECHNOLOGY TRANSFER: LAND APPLICATION OF MUNICIPAL SLUDGE**

OBJECTIVE:

To maximize technology transfer in the field of municipal sludge utilization.

RELEVANCE:

During the past several years extensive laboratory and field studies have been conducted to define optimal sludge treatment and utilization options. Much of this information is not extensively used due to the lack of suitable technology transfer mechanisms. Since major cost reductions are likely to be achieved by implementing the technology, dissemination of this information will be pursued by a variety of formats.

WORK PLAN:

1) Continue participation in the Commission of European Communities, Treatment and Use of Sewage Sludge Program. Participation during 1989-90 will include a Swedish "Workshop on Municipal Sludge Treatment and Disposal", Stockholm, April 11-12 and an International Workshop on "Alternative Uses for Sewage Sludge", York, U.K., September 5-7.
2) Promote transfer of best practicable sludge utilization/disposal technology by providing technical assistance to Federal, Provincial and Regional authorities and assisting with the organization of a biennial Canadian Workshop on Sludge Utilization on Land.
3) Serve as Environment Canada representative on the Agriculture Canada - Expert Committee on Soil and Water Management.
4) Serve as Environment Canada representative on the Ontario Soil Management Research Committee and its Waste Utilization & Environmental Quality Subcommittees.

STATUS REPORT - JUNE 1989

M. Webber made two presentations entitled "Land application of municipal sludge in Canada: An overview" and "Municipal Sludge, Organic Contaminants and Agricultural Utilization" to a Land Application of Sludge Workshop held in Stockholm, Sweden, April 11- 12. In addition, the Environment Canada "Land Application of Sludge" display and audio-visual presentation were shown at the Workshop and attracted much interest and favourable comment.

A poster presentation entitled "The persistence of organic contaminants in soils treated with municipal sludge" by J.D. Goodin and M.D. Webber was made to the PCAO Annual Meeting held in Hamilton, April 24-25.

M. Webber prepared an article entitled "Municipal sludge, organic contaminants and agricultural utilization" for the August 1989 issue of the WTC Newsletter.

M. Webber participated in a Canadian Standards Association sponsored meeting on May 30, to develop guidelines for low pollution paints. Following adoption of the guidelines, products meeting them will be identified to consumers by a special label.

A paper entitled "Resource recovery through unconventional uses of sludge" is in preparation for an international workshop on Alternative Uses for Sewage Sludge to be held in York, UK, September 5-7 1989.

STATUS REPORT - SEPTEMBER 1989

M. Webber attended the AIC Conference and Canadian Society of Soil Science annual meeting in Montreal, July 9-13. A paper entitled "Greenhouse studies with 14C-labelled organic contaminants" authored by J.D. Goodin and M.D. Webber was presented to the CSSS meeting by J. Goodin. A poster paper entitled "Persistence of volatile organic contaminants (VOC) in sludge treated soils" by J.D. Goodin and M.D. Webber was presented to the CSSS meeting by M. Webber.

M. Webber attended an international workshop on Alternative Uses for Sewage Sludge in York, UK, September 5-7, 1989 and presented an invited paper entitled "Resource recovery through unconventional uses of sludge".

STATUS REPORT - DECEMBER 1989

M. Webber hosted and participated in the CASCC, Expert Committee on Soil and Water Management meeting held, October 19 & 20 at CCIW. A brief explanation and tour, respectively, of CCIW programs and facilities was arranged for the afternoon of October 20.

M. Webber attended meetings of the Ontario Sludge and Waste Utilization Committee at Guelph, October 31 and December 12.

M. Webber presented a paper entitled "Municipal Sludge, Organic Contaminants and Agricultural Utilization" to a PCAO/MOE Seminar on Fate of Chemicals in Sewage Treatment Facilities, held in London, Ontario, November 23. A proceedings was published and distributed at the Seminar.

M. Webber made a presentation entitled "The Potential for Uptake of Organic Contaminants by Crops Treated with Sewage Sludges from Wastewater Treatment Plants" to the Niagara Environmental Task Force (NET Force) at Brock University, November 8.

STATUS REPORT - MARCH 1990

M. Webber participated in a planning committee meeting for the 1992 Canadian Society of Soil Science annual meeting. The meeting was held in the University of Alberta, Soil Science Department on February 12. On February 13, he travelled to the Alberta Environmental Centre where he discussed research programs with people in the Plant Science Division and presented a seminar entitled "Land Application of Sewage Sludge: A State-of-the-Art. The same seminar was presented to the University of British Columbia, Soil, Science Department, February 14. February 15 and 16 he participated in the B.C. Soil Science Lead Committee workshop where he reported on WTC studies of the persistence and fate of organic contaminants in municipal sludge applied to land.
M. Webber was invited to visit the INRS Eau, Complexe Scientifique, Universite du Quebec, Quebec, March 2 to discuss land utilization of municipal sludge and to present a seminar on this topic. The title of the seminar was the same as that presented in Alberta and British Columbia.

DIVISION: **RESIDUE MANAGEMENT** **PROJECT MGR: H.W. CAMPBELL**

PROJECT NO: 68347 **TEL: (416) 336-4717**

TITLE: **LAND APPLICATION OF INDUSTRIAL WASTES**

OBJECTIVE:

1) To determine the fate and treatability of industrial waste constituents through application to soil under a variety of environmental conditions and management practices.
2) To extend the available Canadian database regarding fate and treatability of waste constituents in soil through cooperation and transfer of expertise and technology with agencies in other countries.

RELEVANCE:

Appropriately managed, application of solid waste to land has potential as a cost effective method of waste treatment resulting in ultimate disposal for a number of Canadian industries. Currently, however, there is an insufficient database available regarding the environmental impact of a large number of organic and inorganic constituents of industrial wastes when applied to soil. The US EPA is currently developing an extensive database regarding degradation and transport of organic constituents of industrial wastes. A comparable Canadian effort is required to compile and expand upon the international database relevant to Canadian environmental conditions and to provide information required by Canadian managers for development of guidelines for land application of industrial wastes.

WORK PLAN:

1) Incubation study using mixtures of heavy oil wastes in soil to identify rates of degradation for target organic constituents with a variety of environmental conditions and management practices.
2) Microcosm studies to assess leaching, volatilization, degradation and plant uptake of target organic constituents, transport of inorganic constituents and toxicity of leachate under a variety of environmental conditions and management practices.
3) Participate in USEPA meetings to exchange information and technical expertise.
4) Provide technical advice and project review for PERD and other EC supported research in the area of industrial waste disposal.
5) Prepare a final report of project results for PERD.

STATUS REPORT - JUNE 1989

Persistence and Fate of Aromatic Constituents of Heavy Oil Production Waste Applied to Soil

A PERD annual project report for 1989/90 and a proposal and budget for 1990/91 was prepared and submitted to Richard Scroggins.

A project technical position was vacated in early April but a replacement was found and there was no significant disruption to the project.

Saskatchewan sludge was prepared for use in several experimental procedures including the kinetic/incubation study (part II).

Saskatchewan soil (intact core) microcosms were assembled and are presently undergoing KBr breakthrough curve analyses in preparation for the Microcosm 4 study. This study will assess management techniques that could be used in situ to minimize oily waste contamination levels in landfarm soils. Radio-labelled 2-methylnaphthalene was ordered for this study.

Sorption isotherms for three target chemicals in three soil types are proceeding on schedule with the soil/water phases for partitioning coefficient determination nearing completion. Phase partitioning
studies using water/waste mixtures will then be performed.

Preparation of the kinetic/incubation study (part II) involving pure chemical addition to a soil/oily waste matrix was delayed due to lack of analytical support. Spiked chemical solutions have been prepared by the analytical section and the waste matrix is now being tested for recovery of the target chemicals. This process will determine the applicability of present methods of analyses.

T. Bulman and K. Hosler met with R. Scroggins to discuss the interim PERD report preparation as well as completion of the laboratory work.

STATUS REPORT - SEPTEMBER 1989

On NSERC request, M. Webber reviewed an NSERC Cooperative Research and Development project entitled "Industrial waste management through enhanced land treatment". The project is being conducted by the University of Guelph with cooperation and support from the Institute for Chemical Science and Technology. The project leader is Dr. R.P. Voroney of the University.

M. Webber was invited and agreed to serve as a reference in relation to Dr. Voroney's consideration for tenure within the University of Guelph, Department of Land Resource Science.

Sorption isotherm determinations for three target chemicals in three soil types were completed. A final draft report for this study was prepared.

The kinetic/soil incubation study (Part II) involving pure chemical addition to a soil/oily waste matrix is continuing, with an expected completion date of November 23 (119 days). Samples from the first three periods have been analyzed for target chemicals and the results are presently being tabulated. Soil-water extracts have been submitted to the toxicity testing laboratories in Longueuil, Quebec.

Computer modelling of waste movement in both the microcosm and kinetic studies commenced in August. Model predictions will be compared to the experimental results and will be incorporated into the final interim report due January 1, 1990.

Set-up of the Saskatchewan soil (intact core) microcosm study was delayed due to problems in acquiring supplies, however the experiment is now in progress. Sludge was

incorporated into the soil and chemical spiking was performed on September 8. The anticipated termination date for this study is January 8, 1990.

K.R. Hosler attended the "Fourth Conference on Petroleum Contaminated Soils" in Amherst, Mass. on September 25-28 where an updated version of the paper entitled "Environment Canada research on land treatment of petroleum wastes" was presented by B.E. Jank.

A PERD Project Six-Month Status Report for FY 89/90 was prepared and submitted to R.P. Scroggins on September 30.

STATUS REPORT - DECEMBER 1989

The kinetic/soil incubation study (part II), involving pure chemical addition to a soil/oily waste matrix, was terminated on November 30 (126 days). All samples (10 samples periods) have been submitted for analyses, and results for target chemical concentrations from all sampling periods and for oil and grease concentrations from seven sample periods have been received and tabulated. No results have been received on the soil-water-extracts that were submitted to the toxicity testing laboratories in Longueuil, Quebec.

Data manipulation/analyses and computer modelling of waste movement, in both the microcosm and kinetic studies, continues. A rough draft of the final interim PERD report, due January 12, 1990, was prepared and is being reviewed by T.L. Bulman.

Final sampling from the Saskatchewan soil (intact core) microcosm study was performed on December 13 after the 14th week of operation. Column dismantling will take place in early January with soil analytical results due by the end of March, 1990.

STATUS REPORT - MARCH 1990

Dismantling of the Microcosm III Study soil columns was completed at the end of January, and soil samples were submitted for analysis of pH, EC, moisture content, oil and grease, 14C-labelled target chemical (2-methyl-naphthalene), chemical metabolites, and nutrients. Approximately 50% of the analyses have presently been completed. Analysis of samples by GC/MS cannot be performed until later in the year due to manpower limitations in the analytical laboratory.

A contract for completing all studies and reports related to this project was awarded to K.R.H. Environmental Inc., effective Jan. 11 to Dec. 31, 1990.

The final interim report and PERD annual status report for this project were prepared and are being reviewed internally.

Preparation of equipment and ordering of supplies for the final biometer flask were initiated. The anticipated start-up date for this experiment is May 1, with a duration of 3 months. Laboratory space with incubation facilities is presently being secured for this experiment.

DIVISION: **RESIDUE MANAGEMENT** **PROJECT MGR: T.W. CONSTABLE**

PROJECT NO: 68348 **TEL: (416) 336-4716**

TITLE: **MANAGEMENT STRATEGIES FOR INCINERATOR RESIDUES**

OBJECTIVE:

To provide technical assistance and professional support with respect to ultimate disposal strategies for incinerator residues.

RELEVANCE:

Future management strategies for municipal solid waste and industrial hazardous wastes will include incineration technologies as a preferable alternative to landfilling. Preliminary characterization studies of these incinerator residues indicate that a significant proportion of the constituent heavy metals are highly mobile. Detailed evaluation of the residues is required to aid in developing regulatory criteria. Development of treatment technologies for ultimate disposal is also warranted.

WORK PLAN:

1) Provide support to the National Incinerator Testing and Evaluation Program (NITEP) by:
   a) conducting characterization studies on the residues from various types of municipal solid waste incinerators;
   b) assessing technologies for the immobilization of inorganic contaminants in these residues;
   c) providing general input to the NITEP program.
2) Coordinate efforts with the US EPA on research into incinerator residues and feasibility studies on immobilization technologies.
3) Support U/P's and other proposals that address incineration technologies.

STATUS REPORT - JUNE 1989

T. Constable and S. Sawell attended the International Conference on Municipal Waste Combustion held in Hollywood, Florida, April 11-14. S. Sawell presented a paper entitled "The National Incinerator Testing and Evaluation Program: Characterization of Residues from a Refuse Derived Fuel Combustion System and a Modular Municipal Waste Incinerator". He also chaired one of the sessions, participated in a panel discussion, and attended meetings of the IEA Sub-committee on Downstream Effects of Source Separation in Municipal Waste Combustion.

Data from the characterization tests conducted on ashes from the Greater Vancouver Regional District (GVRD) Energy-from-Waste facility were compiled, and a report on the results is being prepared.

Testing of solidified GVRD fly ash samples began in May. Most of the testing has been completed, with the exception of the dynamic leach and freeze/thaw tests. These are expected to begin in July. Samples from the Mid-Connecticut RDF test program were received at the WTC on May 30. The samples were subjected to the SBEP and the resulting leachates were submitted to River Road Laboratories for organic analyses.

Sample collection at the London 3M Energy-From-Waste facility began on May 31 in conjunction with air emission compliance testing. S. Sawell toured the facility on May 30 to inspect ash sampling ports and to ensure that the necessary process parameter data would be monitored during sample collection. He also met with staff from IMET, MOE and 3M to discuss final testing arrangements. Samples were received at the WTC on June 5.

J. Neate, T. Constable and S. Sawell met with IPB and CPG staff in Ottawa on May 24 to discuss the NITEP ash program status.

The first draft of the report "Evaluation of Solidified Fabric Filter Ash from a Modular Municipal Waste Incinerator With Lime-based Air Pollution Control" was submitted to WTC on May 18. The second draft of the report was submitted to IPB for comments on May 24.
Final copies of the reports entitled "Evaluation of Contaminant Leachability from Residues Collected at a Refuse Derived Fuel Municipal Waste Combustion Facility" and "Evaluation of Solidified Electrostatic Precipitator Ash From a Mass Burning Municipal Waste Incinerator" were submitted to IPB for publishing in the Manuscript Series. The report entitled "The National Incinerator Testing and Evaluation Program: Characterization of Residues from a Modular Municipal Waste Incinerator With Lime-based Air Pollution Control" is currently in the WTC approvals process.

An abstract entitled "Evaluation of Solidified Fly Ash from a Mass Burning Municipal Waste Incinerator With Lime-based Air pollution Control Devices" was submitted for presentation at the 11th Annual Canadian Waste Management Conference to be held in Montreal, September 26-29, 1989.

An abstract entitled "Evaluation of Solidified Fly Ash from a Modular Municipal Waste Incinerator" was submitted for presentation at the American Institute of Chemical Engineers Annual Meeting to be held in Philadelphia, August 22-24, 1989.

STATUS REPORT - SEPTEMBER 1989

NITEP

Laboratory testing was completed on ashes from the Mid-Con and 3M incinerators, and on solidified fabric filter ash from the Greater Vancouver Regional District (GVRD) incinerator. Leachates from the Mid-Con ashes were submitted to River Road Laboratories for organic analysis on July 10. Leachates from the 3M ashes were submitted to Ontario Ministry of the Environment Laboratories for organic analysis on September 5.

Evaluation of preliminary solidification formulations for the Mid-Con and Dayton ashes began in late September.

S. Sawell attended a meeting of the US EPA's Advisory Committee on the Stabilization/Solidification of MSW Incinerator Ash at the New Jersey Institute of Technology in Newark, New Jersey, on July 10.

T. Constable met with staff from IPB, Ontario MOE, Montenay-Birwelco and EM&R in Ottawa on July 13 to discuss a proposed study to vitrify MSW ash. A proposal for the WTC to evaluate the characteristics of the resulting vitrified material was prepared and submitted to IPB.

A paper entitled "Evaluation of Solidified Ash from a Modular Municipal Waste Incinerator" was prepared and presented at the annual meeting of the American Institute of Chemical Engineers held August 20-23, 1989, in Philadelphia, PA. The paper is currently being considered for publication in the AIChE Journal.

A paper entitled "Evaluation of Solidified Fly Ash From Municipal Waste Incineration" was prepared and presented at the 11th Annual Canadian Waste Management Conference held September 26-29, 1989, in Montreal, Quebec.

The reports entitled "Evaluation of Solidified Electrostatic Precipitator Ash from a Mass Burning Incinerator", "Evaluation of Contaminant Leachability from Residues Collected at a Refuse Derived Fuel Municipal Waste Combustion Facility" and "Characterization of Residues From a Modular Municipal Waste Incinerator With Lime-based Air Pollution Control" were published as Environment Canada Manuscript Series reports.

The first draft of the report entitled "Characterization of Residues From a State-of-the-Art Mass Burning Municipal Waste Incinerator" was prepared and is being reviewed internally.

STATUS REPORT - DECEMBER 1989

NITEP

All laboratory tests were completed on the ashes from the Montgomery County, Mid-Con and 3M incinerator facilities. Testing of the solidified specimens from Mid-Con and Montgomery County ashes is scheduled to begin in early January. The results of the tests and analyses conducted on the Mid-Con ashes are being compiled.

The report entitled "Characterization of Residues from a State-of-the-art Mass Burning Municipal Waste Incinerator" is currently being revised to incorporate comments from IPB and GVRD staff.

The first draft of the report entitled "Evaluation of Solidified Fabric Filter Ash from a Mass Burning Municipal Waste Incinerator" is being written.

T. Constable and S. Sawell met with staff from IPB and the Ontario Ministry of the Environment in Toronto on October 25 to discuss the status of current NITEP ash characterization studies.

S. Sawell made a presentation on "The Evaluation of Solidified Fly Ash from MSW Incinerators" at the 2nd International Conference on Ash Utilization and Stabilization held in Arlington, Virginia, November 8-9, 1989.

The report entitled "Characterization of Residues from a Modular Municipal Waste Incinerator with Lime-based Air Pollution Control" was published in December. H. Campbell, T. Constable and S. Sawell met with J. Adams, legal counsel for the Township of Westminister, Ontario, on December 18 to discuss the contents of this report.

STATUS REPORT - MARCH 1990

NITEP

Most of the laboratory tests on the untreated and solidified ashes from the Montgomery County (Dayton) and Mid-Con incinerator facilities were completed. The freeze/thaw durability, acid neutralization, ANS 16.1 and hydraulic conductivity tests were initiated and are scheduled for completion by early May.

S. Sawell reviewed the "MSW Ash Summary from the U.S. Conference of Mayors Workshop on Incineration" and submitted formal comments to WMB in January.

S. Sawell made a presentation summarizing the NITEP ash characterization studies completed to date at the "Workshop on Heavy Metals in Municipal Solid Waste" held in Research Triangle Park, North Carolina, January 30-31. The workshop was sponsored by the International Lead and Zinc Research Organization.

S. Sawell met with R. Klicius of WMB on Feb. 6 to review the status of the NITEP ash program and to discuss changes to the report "Evaluation of Solidified Fabric Filter Ash from a Mass Burning Municipal Waste Incinerator (Burnaby, B.C.)". This report is on hold, awaiting written interpretation of the biotoxicity test results by R. Scroggins.

An abstract entitled "Ash Characterization Studies Under the National Incinerator Testing and Evaluation Program" was submitted for presentation at a symposium entitled "Municipal Solid Waste Management: Making Decisions in the Face of Uncertainty" to be held in Toronto, April 25-27, 1990. The symposium is being organized by the University at Waterloo's Institute for Risk Research and is sponsored by Environment Canada, Ontario Ministry of Energy and the Ontario Ministry of the Environment. A paper is currently being prepared.

An abstract entitled "The National Incinerator Testing and Evaluation Program: Characterization of Residues from a Refuse Derived Fuel Incinerator" was submitted for presentation to the 12th Annual Canadian Waste Management Conference to be held in St. John's, Newfoundland, Oct 2-5, 1990.

The report entitled "Characterization of Residues from a State-of-the-art Mass Burning Municipal Waste Incinerator (Burnaby, B.C.)" was completed, and has been submitted for publication in the manuscript series.

The first draft of the report entitled "Characterization of Residues from a Refuse Derived Fuel Combustion Facility (Mid-Connecticut)" was completed in mid-March and reviewed internally. The second draft was completed in late March and will be sent to WMB and US EPA in April for comments.

DIVISION: RESIDUE MANAGEMENT **PROJECT MGR:** ALL

PROJECT NO: 66349 **TEL:** –

TITLE: TECHNICAL REVIEWS: PROPOSALS, REPORTS, PAPERS

OBJECTIVE:

To review proposals, reports and manuscripts relevant to Residue Management.

RELEVANCE:

Technical expertise in the Residue Management Section is well suited to the critical review of these documents.

WORK PLAN:

Provide reviews on an as requested basis.

STATUS REPORT - JUNE 1989

No activity.

STATUS REPORT - SEPTEMBER 1989

No activity.

STATUS REPORT - DECEMBER 1989

A number of manuscripts for the 1990 IAWPRC in Japan were reviewed by H. Campbell and M. Webber.

A proposal concerning the destruction of organic wastes by Dr. Rosenfeld of McMaster University was reviewed.

M. Webber reviewed a manuscript entitled "Irradiation-pasteurized sludge: Effects on microorganisms, nutrients and heavy metals" submitted for presentation to the CAWPRC.

M. Webber reviewed an NSERC research grant proposal.

STATUS REPORT - MARCH 1990

As associate editor for the Journal of Environmental Quality, M. Webber reviewed one manuscript entitled "Adsorption, degradation, and plant availability of 2,4-dinitrophenol in sludge-amended calcareous soils".

M. Webber reviewed a research proposal submitted to the Science Council of British Columbia entitled "Recycling urban sewage sludge and other organic waste as slow-release forest fertilizer", and an Agriculture Canada proposal concerning interagency collaboration on recycling of organic wastes.

DIVISION: RESIDUE MANAGEMENT **PROJECT MGR:** H.W. CAMPBELL

PROJECT NO: 68350 **TEL:** (416) 336-4717

TITLE: DEMONSTRATION OF SLUDGE CONVERSION TECHNOLOGY

OBJECTIVE:

To oversee the performance evaluation of a 1 tonne/day demonstration conversion reactor system in support of the commercialization of the technology. Provide technical support to the licensee of the oil from sludge technology.

RELEVANCE:

The oil from sludge technology has progressed to the pilot validation phase and a 1 tpd unit is operating at the Hamilton STP. This phase of the program will assess both the technical and commercial viability of the technology. Support will be provided to the licensee to commercialize the technology as rapidly as possible.

WORK PLAN:

1) Operate the 1 tpd pilot plant to generate large volumes of oil for an engine testing program.
2) Support the licensee in the design and siting of the first full-scale demonstration plant.

STATUS REPORT - JUNE 1989

A proposal for an OFS demonstration facility for Highland Creek STP was presented to Metro Toronto personnel on May 3. The proposal was reviewed by their consultants and a meeting is scheduled for July to discuss technical questions.

Meetings were held with NRC to discuss their program for the coming year.

H. Campbell presented a paper entitled "Converting Sludge to Fuel - A Status Report" at the 19th National Conference on Municipal Sewage Treatment - Plant Sludge Management, New Orleans, June 2.

H. Campbell met with Prof. Bayer at Tubingen University to discuss the status of OFS commercialization in Europe. Discussions were also held with Mr. K. Morris who is interested in OFS for the U.K.

H. Campbell met with representatives of Still Otto GmbH in Dusseldorf, West Germany to discuss progress on their pilot plant. They are designing a 10-12 t/d plant to be located near Dusseldorf. They have funding of 17 M Germany marks which includes the capital cost of the plant, and a 1 year test program. Expected completion date of the plant is late 1990.

H. Campbell and B. Jank met with Underwood MacLellan, the Halifax Technical Advisory Group and a local environmental action group in Halifax to discuss OFS technology.

The OFS exhibit was on display at the Annual PCAO conference in Hamilton. CBC filmed a segment on OFS on May 26 for broadcast on the Journal diary.

STATUS REPORT - SEPTEMBER 1989

Several meetings were held with Metro Toronto and their consultants to discuss the potential demonstration facility at Highland Creek. A proposal for a full-scale plant was submitted by SNC and was modified to address specific Metro concerns. Discussions are ongoing as to potential methods of funding the project.

H. Campbell and D. Martinoli met with the City of Edmonton on July 25 to discuss an OFS demonstration unit. They have subsequently identified their objectives and are waiting for a response from Enersludge.

Discussions were initiated with the City of Houston for the installation of an OFS demonstration unit. Since Houston are already drying their sludge, the demonstration would consist of only the conversion unit. A proposal was submitted by WTC to conduct pilot scale conversion trials on their sludge.

STATUS REPORT - DECEMBER 1989

A six month status report and financial statement was prepared for the PERD meeting on October 6.

Discussions were held with municipal officials from Houston, New York and Edmonton regarding potential OFS demonstration projects.

A final technical proposal for the demonstration plant at Highland Creek was submitted by SNC. A meeting was held with ISTC officials on November 9 to discuss potential Federal funding for this plant.

Mr. H. Winck of Still Otto, Germany spent several days at the WTC observing the operation of the OFS pilot plant and collecting product samples. It has been agreed that WTC will ship 500L of oil to Still Otto, who will conduct diesel engine tests and provide the results to WTC.

STATUS REPORT - MARCH 1990

A sample of pilot plant oil (500 L) from Atlanta sludge was shipped to Still Otto, Germany for diesel testing. Results are not yet available.

Tentative arrangements to test two sludges from Houston, Texas were completed but the sludges have not been received.

A meeting was held with SNC/Metro Toronto on March 28 to address any requests by Metro for additional information. Efforts continued to finalise the funding package for the proposed Highland Creek demonstration project.

DIVISION: RESIDUE MANAGEMENT **PROJECT MGR:** H.W. CAMPBELL

PROJECT NO: 68351 **TEL:** (416) 336-4717

TITLE: CONVERSION OF RESIDUES TO LIQUID AND SOLID FUELS

OBJECTIVE:

To generate process design information from a lab scale continuous reactor for a variety of source materials and assess oil upgrading technologies.

RELEVANCE:

Canada produces about 500 000 tons of sewage sludge annually, which is disposed of at a cost of approximately $105 million. Recent research has indicated that sewage sludges can be thermally converted to synthetic oil and char. The first phase of this study has demonstrated that Canadian sludges are amenable to processing and a continuous reactor system has been designed and operated to generate preliminary process design information for a one tonne per day pilot plant facility.

WORK PLAN:

1) Expand process design data base with information from additional municipal sludges.
2) Evaluate alternative source materials, e.g., refuse, animal wastes, etc.
3) Conduct experiments to answer specific questions with respect to design of pilot system.

STATUS REPORT - JUNE 1989

Bench tests were completed on the Highland Creek sludge to provide data for the OFS proposal. Average yields obtained were 28% oil and 50% char.

The bench scale reactor has been modified to incorporate a fractional condensation system. The system includes a train of three condensers operating at different temperatures. Preliminary runs have been completed but additional modifications to the first condenser are required.

STATUS REPORT - SEPTEMBER 1989

A number of runs were conducted with the fractional condensation system. The first condenser was operated at 300°C, the second from 100-150°C and the third at 30°C. The product split varied with the temperature of the second condenser but was generally in the range of 15-20% in the first, 40-50% in the second and 30-45% in the third. Unfortunately, the oils from the second and third condensers still contained significant quantities of water, averaging about 7% in the second and 15-20% in the third. Additional characterization of the separate fractions is ongoing.

A meeting with CANMET, SNC and WTC was held on September 13. Options for upgrading the oil and/or direct end-use were discussed. CANMET are interested in a joint program with WTC and SNC to develop and evaluate these options. They are preparing a proposal for consideration by mid-October.

STATUS REPORT - DECEMBER 1989

A CANMET proposal for characterization and upgrading studies on sludge derived oil has been initiated. This is a joint program supported by CANMET, SNC and WTC. The objectives of the program are to characterize the oil, to examine conventional and non-conventional methods of water removal and upgrading, and to evaluate various end-use options based on the characterization data. Approximately 350L of oil have been delivered to CANMET to conduct the program. The time frame of the program is approximately six months.

STATUS REPORT - MARCH 1990

A progress review meeting was held in March to discuss the joint WTC/SNC/CANMET program. Studies on the removal of water and the characterization of the resulting oil are proceeding well. A number of novel options for the use of the oil were identified and preliminary evaluation is in progress.

DIVISION: RESIDUE MANAGEMENT **PROJECT MGR:** H.W. CAMPBELL

PROJECT NO: 68352 **TEL:** (416) 336-4717

TITLE: ENVIRONMENTAL ASSESSMENT OF SLUDGE CONVERSION TECHNOLOGY

OBJECTIVE:

To assess the impacts of combustion of the synthetic fuel produced by the oil from sludge technology.

RELEVANCE:

The sludge conversion technology developed at the WTC appears to have considerable commercial potential and may well form the basis for a significant portion of the future sludge management market. The technology is unique and the full potential environmental impact of this technology needs to be assessed.

WORK PLAN:

Under a U/P submitted by Dearborn Environmental, an integrated process/analytical system has been constructed to permit assessment of PAH/HNC emissions from the sludge conversion process. Emissions from the combustion of the synthetic fuels produced by the oil from sludge technology will be assessed using this equipment.
Act as Scientific Authority on this contract.

STATUS REPORT - JUNE 1989

Work on this project was commenced with the first task being the modification of the method parameters. This would allow for the automatic identification and quantitation of the components of oil extracts using the ion trap. This modification was necessary to accommodate the installation of a new 60 metre column. Performance parameters vary with every new column installation and therefore these parameters needed to be re-established. In addition, a new piece of custom software was written to facilitate the generation of run reports.

Early in the quarter, progress was slow due to staff vacations. Continuing problems concerning available computer memory plagued the project. Because of the size of the ion trap files, available memory was used up very quickly. The tape backup system which was purchased to enable the rapid mass storage of archived data did not function properly. It proved to be unwieldy and subsequently a second system was ordered. This system arrived in June and was installed shortly thereafter. The new streaming tape backup system works well and will cure the memory shortage problem.

The ion trap was not functioning properly due in part to the two scheduled power shut downs. These shut downs required that all instrumentation in the lab be turned off for two consecutive weekends. The ion trap did not come back up properly which necessitated calling a service man. It is expected that as soon as the instrumentation problems have been overcome, analytical work will proceed quickly.

STATUS REPORT - SEPTEMBER 1989

All the instrumentation problems were solved and MDGC-ITDS is back in full operation. An analytical quantitating method for 94 compounds (45 hydrocarbons, 26 PAH, 23 HNC) was developed and tested. The internal standard method using d^{12}-benzo(a)anthracene as IS has been used for analysis of the samples generated from the thermal destruction tests of two diesel fuels and five oils from sludges. Analyses were performed on a fused silica capillary column DB-5 (60 m, 01.24 mm ID, 0.2µm df). UHP hydrogen was used as a carrier gas. Modified PTV was used for cold on-column injection.

Analysis of all samples generated with the oils have been completed. Collected data was summarized in tabular form to show:

a) the composition and recovery achieved by fractionating into four chemical classes;
b) the composition and recovery of the oils analyzed directly without fractionation;
c) the composition and recovery of the oils from the TGA without thermal destruction. These data are used as a starting point (base data) for the calculation of the destruction parameters and destruction efficiency.
d) the composition and products of incomplete combustion (PIC's) at 550°C, 700°C, 850°C and 950°C with the reaction times (in HTR) ranging between 0.5 - 3 seconds.

Data from c) and d) are used for the calculation of the thermal destruction kinetic parameters and destruction efficiencies.

The overall data shows very low recovery by the method using fractionation into four chemical classes. However direct analysis of the oils after solubilization in mixed solvent gives high recovery. Recoveries of the oil samples generated by the TGA and trapped in a mixed solvent are significantly higher than from the chemical class separation method.

Preliminary data indicates that a temperature of 850°C with two seconds reaction time is sufficient to achieve 99.99% destruction. At a reaction time of three seconds, a very significant part of the PIC's are newly formed hydrocarbons with chain lengths of C^{22} to C^{23}. For example, these hydrocarbons are hardly detected at 1 (one) second reaction time at 850°C, however at three seconds reaction time each of C^{22} to C^{22} chains is present.

It is not known what type of reaction (could be catalytic) takes place to form these higher chains of hydrocarbons, however it is a fact which must be considered in the evaluation of the impact of PIC's on the environment.

STATUS REPORT - DECEMBER 1989

Thermal destruction tests of oils from sludge and analysis of samples generated for kinetic parameters evaluation were completed. Data from 2 diesel fuel samples and 5 oil samples have been summarized. Quantitation of hydrocarbons, PAH and HNC was done by two methods:

a) chemical class separation
b) direct analysis without sample treatment

Data from both methods show low recovery. Higher recoveries are achieved by the direct method.

Samples for kinetic data generation were analyzed by direct method only.

Destruction studies were performed at temperatures of 550°C and to 950°C with residence times of 0.5 to 3 seconds. Kinetic data was used for the calculation of temperatures required for 99.99% destruction at 2 seconds residence time in HTR. To achieve 99.99% destruction a temperature of 737°C was required (based on the recovered portion of the sample), which indicates that the material in the sample is thermally fragile.

A unique phenomena was observed during the kinetic study. With an increase of reaction temperature to 700°C and especially to 850°C and with an increase of reaction time in HTR to 3 seconds, the formation of hydrocarbons with higher numbers of carbon such as C24 ---- C32 were observed. These newly formed compounds were not detected at a residence time of 1 second. The formation of new compounds is well documented in the report. This observation suggests that 99.99% destruction of original (parent) compounds may not be sufficient due to the formation of new compounds of higher molecular weights which may be more stable than the parent compound.

An unscheduled power shut down caused damage to the ITDS. The multiplier and some other parts have been replaced and the instrument is expected to be operational by January 1990.

STATUS REPORT - MARCH 1990

Activity on the project continued to be limited due to operational problems. The progress report was finalized and is being reviewed by WTC. A sample of the bench scale oil from Highland Creek sludge was submitted for characterization.

DIVISION: **RESIDUE MANAGEMENT** **PROJECT MGR: H.W. CAMPBELL**

PROJECT NO: 68354 **TEL: (416) 336-4717**

TITLE: **DEGRADATION OF CHLORINATED ORGANICS IN SOIL SYSTEMS**

OBJECTIVE:

1) To develop an in-situ process for the biodegradation of pentachlorophenol using inoculants of microorganisms absorbed on granular activated carbon.
2) To develop an on-site process to leach pentachlorophenol from contaminated soil followed by biological degradation.

RELEVANCE:

Substantial quantities of soil contaminated with chlorinated organic compounds, including PCP's, are currently awaiting a suitable method for cleanup and disposal. Given the volume of soil involved, the potential for spillage during extensive transportation to incinerator facilities and the high cost of incinerating soil with a relatively low content of ignitable material, it is appropriate to explore alternative methods of treatment for contaminated soil. Microbial degradation by native soil organisms or selected PCP degrading strains in a controlled and contained incubation system may provide a cost effective solution which can be implemented on a contaminated site.

WORK PLAN:

A U/P submitted by Dearborn Environmental Inc. will develop unique processes which will effectively decontaminate soils containing toxic wood treatment chemicals (PCP's).

To act as Scientific Authority on the project.

STATUS REPORT - JUNE 1989

Four additional pentachlorophenol biodegradation experiments were either completed (#2), or are under way (#3, #4 and #5). The results of experiment #2 yielded additional insight into prerequisites for establishment of a PCP degrading bacterial population in contaminated soil. The results of experiment #3 indicate that the rate of PCP biodegradation can be increased by a variety of soil amendments, including addition of metabolizable carbon, surfactant and increasing soil water content. A combination of the amendments is more beneficial than any individual amendment. Maximum biodegradation rates were approximately 1.5% per day. Initial results of experiment #5 indicate that further enhancement of PCP biodegradation can be achieved by optimizing the concentration of metabolizable carbon. Preliminary results indicate a biodegradation rate of approximately 5% per day has been attained.

Experiment #4 is designed to reveal a potential biochemical limitation to the rate of PCP decomposition, however the results are not yet available.

Native microorganisms tolerant to PCP have been isolated from an Ontario soil and their PCP-degradative ability is being determined.

Agreements were reached with two suppliers of commercial microbial inocula for bioremediation of PCP contaminated soil. The efficacy of the products will be evaluated in a laboratory study.

Data from leaching studies indicate that significant reduction in soil PCP concentration can be attained by alkaline leaching.

STATUS REPORT - SEPTEMBER 1989

Studies to elucidate the optimal physical/chemical environment for microbial biodegradation of chlorophenols continue. Since the last quarterly report, several experiments have been completed (#3, #4 and #5) while others (#6, #7, #8) have been initiated. The results of experiments #3 and #5 yielded additional insight into the requirements for effective removal of PCP from soil. The results of experiment #5 indicate that the rate of PCP biodegradation can be increased several-fold (over that in unamended soil) through application of a physical/chemical/biological soil treatment and that the concentration of PCP in soil contaminated by wood treatment can be reduced from approximately 150 mg/kg to less than 1 mg/kg in 11 weeks. Preliminary results of a new experiment (#7) indicate that a similar biodegradation rate was achieved in more highly contaminated (1000 mg/kg) soil. Biodegradation of PCP in soil containing more than 400 mg PCP/kg has not been demonstrated elsewhere.

Characterization of a national range of PCP contaminated soils is nearly complete.

New studies will examine the applicability of the physical/chemical/biological soil treatment method to decontamination of the above mentioned soils.

STATUS REPORT - DECEMBER 1989

Studies to elucidate the optimal physical/chemical environment for microbial biodegradation of chlorophenols continued.

A number (15) of pure cultures of PCP tolerant bacteria were isolated from wood treatment soils from several provinces.

A screening protocol to compare the PCP catabolic abilities of the bacterial isolates was completed. The results indicated that the Flavobacterium strain obtained from ATCC possessed the greatest ability to degrade PCP.

A biometer flask study to determine the influence of biosurfactant on biodegradation of PCP was completed. The results indicated that addition of biosurfactant did not increase the rate of PCP biodegradation by Flavobacterium.

Results from Experiment VI indicate that the technology employed in earlier studies with moderately PCP-contaminated soils (200 mg/kg) is applicable to more highly contaminated soils (1300 mg/kg). Total PCP analysis revealed that the concentration of PCP in a wood treatment soil was reduced from approximately 1300 mg/kg to less than 10 mg/kg in 12 weeks.

New experiments to determine if the technology used in the first six biodegradation studies is applicable to six other studies were initiated.

New isolates of PCB degrading bacteria were obtained and successfully cultured.

A phase partitioning study to determine the influence of soil amendments on the solubility of PCP in the soils aqueous phase was completed. Results indicated that amendments which enhanced biodegradation of PCP also reduced its solubility.

Cultures of PCP and PCB degrading bacteria were maintained.

STATUS REPORT - MARCH 1990

The technology used to enhance biodegradation in two Ontario soils was applied to six additional chlorophenol contaminated soils from sites in British Columbia, Ontario, Quebec and Newfoundland. Rapid mineralization of added 14C-PCP in all soils indicates that the patent-pending technology is widely applicable.

Aqueous biodegradation studies to determine the influence of specific ionic species on transport and biodegradation of PCP continued.

Isolation of bacterial cultures from chlorophenol contaminated soils, for comparison to the strain currently being used, continued.

Cultures of PCP and PCB degrading bacteria were maintained.

Scaled-up biodegradation studies were initiated.

DIVISION: RESIDUE MANAGEMENT **PROJECT MGR:** H.W. CAMPBELL

PROJECT NO: 68355 **TEL:** (416) 336-4717

TITLE: TECHNOLOGY TRANSFER: RESIDUE TREATMENT

OBJECTIVE:

To maximize technology transfer in the field of sludge/residue treatment.

RELEVANCE:

In the past few years, major advances have been made in the development of new technology for sludge/residue treatment and the design of integrated sludge management systems. Much of this information is under utilized due to the lack of suitable transfer mechanisms between researchers and users. Improved technology transfer can result in significant economic benefits to municipalities or industries.

WORK PLAN:

1) Continue participation in the Commission of European Community Treatment and Use of Sewage Sludge Program. Participation during 1989/90 will include a meeting of Working Party 1, Sludge Processing in Helsinki, Finland during June.
2) Provide technical assistance to the Industrial Programs Branch, to develop, evaluate and/or promote new cost-effective sludge/residue treatment technology.
3) Actively promote the transfer of state-of-the-art residue treatment technology by participation at seminars, conferences and meetings of municipal officials or public citizens.

STATUS REPORT - JUNE 1989

The CEC meeting scheduled for Helsinki was postponed due to internal CEC problems. It has tentatively been re-scheduled for fall 1989.

STATUS REPORT - SEPTEMBER 1989

No activity.

STATUS REPORT - DECEMBER 1989

H. Campbell attended a workshop in Toledo, Ohio on alkaline pasteurization of sludges using lime and cement kiln dust. This technology is patented and is being marketed by N-VIRO Energy Systems. The workshop included a tour of a full scale plant in Toledo. This technology could have significant application at smaller plants where odours from other processes such as composting may present a problem.

STATUS REPORT - MARCH 1990

P. Crescuolo visited the Banff sewage treatment plant in January to evaluate problems with the belt press. A number of polymers were evaluated and Percol 757 identified as the preferred option. When tested on the press, cake solids of 27% were achieved. Modifications to the instrumentation and control of the belt press were recommended.

H. Campbell made a presentation on "Sludge Treatment and Disposal" at the "Small Community Wastewater Collection and Treatment" seminar at Memorial University, St. John's, February 15-16.

DIVISION: **RESIDUE MANAGEMENT** **PROJECT MGR: T.W. CONSTABLE**

PROJECT NO: 68356 **TEL: (416) 336-4716**

TITLE: **EXPERT SYSTEM FOR ASSESSING SOLID WASTE LEACHING AND DISPOSAL**

OBJECTIVE:

Develop a comprehensive and user-friendly software program to assist in assessing the solid wastes (excluding municipal refuse). The program will combine (1) an expert system,(2) a chemical model to simulate leaching under various disposal conditions, and (3) data bases on known waste properties and leaching characteristics under different leaching test conditions. It will assist in the development of waste disposal scenarios, input of data to the chemical model, recommending laboratory tests, and interpreting laboratory and simulation data with respect to waste leachability, leachate treatment and waste suitability for landfill disposal.

RELEVANCE:

Increased concern over the environmental impact of solid waste disposal has necessitated use of a wide variety of bench-scale leaching protocols to estimate leachability under various disposal scenarios. However, this approach is very expensive and time-consuming. An alternative approach is to combine available expertise on waste leachability as rules in an expert system with a chemical model and databases on waste characteristics, to cost-effectively simulate and measure leaching under a wide range of conditions with a reduced level of bench-scale testing.

WORK PLAN:

1) Provide technical expertise to Dearborn on the knowledge base (rules) structure of the expert system. Information from Proj. 44 will be instrumental in the development of these rules.
2) Compile a data base on chemical and leaching characteristics of coal combustion fly ash.
3) Develop a prototype expert system to guide a user through batch leaching protocol testing and evaluation of landfill disposal options for fly ash.
4) Demonstrate the prototype expert system to potential end-users, obtain feedback and incorporate suggestions.
5) Expand the data base and knowledge base to allow assessments of a wide range of solid waste types.
6) Incorporate chemical model into program, and develop an expert system rule structure to interpret the results of the chemical model.

STATUS REPORT - JUNE 1989

T. Constable and D. Young of Dearborn attended AIRES-89 (The Third Workshop on Artificial Intelligence Research in Environmental Science) in Washington on May 2-4. They also met with staff of Phase Linear Systems Incorporated to discuss expert systems that they are developing.

Dearborn is revising the graphical interface to the LANDIS expert system and preparing a disk-based "slide show" which will interface screen shots of the program with text descriptions of how the program works. When completed, it will be distributed to interested parties for information and comment.

STATUS REPORT - SEPTEMBER 1989

Dearborn completed the disk-based "slide show" which interfaces screen shots of the Landis program with text descriptions of how the program works. Copies of the demonstration diskettes were sent to members of the Technical Advisory Committee, Dr. Hans van der Sloot at the Netherlands Energy Research Foundation, John Matthews and Carlton Wiles of the U.S. EPA, and to S-CUBED, a consulting firm in California which is doing a survey on leachate databases.

STATUS REPORT - DECEMBER 1989

Work continued on development of the icon-mouse graphical interface for the 'HELP' (Hydrological Evaluation of Landfill Performance) model. Extensive editing utilities, simple landfill configurations, and significantly enhanced results reporting capabilities were added.

STATUS REPORT - MARCH 1990

The graphical interface and enhancements for the HELP (Hydrological Evaluation of Landfill Performance) model were completed. Work is continuing on development of the rules in the expert system knowledge base.

An abstract entitled "Development of an Expert System for Assessing the Leaching and Disposal of Solid Wastes" was submitted for presentation at the CHS-90 Symposium on Expert Systems and Statistical Methods in Water Resources to be held May 29-30 at CCIW.

DIVISION: **RESIDUE MANAGEMENT** **PROJECT MGR: T.W. CONSTABLE**

PROJECT NO: 68357 **TEL: (416) 336-4716**

TITLE: **TECHNICAL SUPPORT: INDUSTRIAL SITE DECOMMISSIONING**

OBJECTIVE:

1) To provide technical data and expertise for establishing cleanup criteria for decommissioned industrial sites.
2) To evaluate models which describe the transport of chemicals from the unsaturated zone of soil to routes of human and environmental exposure.

RELEVANCE:

In workshops sponsored by Environment Canada to identify concerns regarding decommissioning of industrial sites, the most critical issue was generally considered to be the determination of cleanup criteria, i.e., "how clean is clean". Various methods for setting cleanup criteria are available, but in many cases do not take into consideration site specific criteria, particularly those concerning transport from contaminated media (usually surface soil) to human and environmental exposure pathways. In 1987 work was initiated to develop a scientifically supportable method for determining site-specific cleanup criteria which combined risk assessment, pathways analysis. A computer model was developed, the Aid for Evaluating the Re-development of Industrial Sites (AERIS). Additional collection of data is required for model evaluation.

WORK PLAN:

1) Complete experimental laboratory studies and assemble data for comparison with computer model outputs.
2) Analyze data collected from the second year of field site monitoring and compare with model-generated values. Improve model characteristics if necessary.
3) Complete sensitivity analysis and field validation with the VIP model for predicting transport of organic and inorganic constituents in the unsaturated zone of soil. Complete AERIS user's guide.
4) Continue to provide technical expertise to the Monenco U/P and the Decommissioning Steering Committee. Provide liaison between Environment Canada and U.S. EPA in studies which evaluate methods of determining cleanup criteria.
5) Complete the final report entitled "Field Evaluation of the Regulatory and Investigative Treatment Zone (RITZ) Model".

STATUS REPORT - JUNE 1989

The repeat microcosm study was completed and samples were submitted for analysis. The results are being tabulated as they are received.

The analyses of Nanticoke landfarm samples (year 2) were completed. The results were tabulated and graphs were made of the organic parameter results.

The first part of the kinetic/incubation study was completed and the results were tabulated. The second part of this study began in May with the following design modifications: (1) addition of a moisturizer to the airstream in order to minimize soil drying, (2) addition of a control flask without sludge, and (3) pure chemical addition in order to ensure that adequate levels of all the target chemicals are present. The second part of the study will be completed by July 7.

The sensitivity analysis of the Vadose Zone Interactive Processes (VIP) model was completed. Validation of the model with year 2 field data was delayed due to errors in the VIP program. These errors are being corrected by the model developers, and validation should commence in July.

T. Constable and K. Hosler met with R. McFarland of Maunsell and Partners Pty Ltd of Australia on April 7 to discuss use of the AERIS model for site decommissioning.

T. Constable and M. Webber reviewed the report "Draft National Guidelines for Decommissioning Industrial Sites" prepared by Monenco Consultants Ltd. M. Webber attended a meeting of the Industrial Site Decommissioning Steering Committee on May 4 to discuss the report. T. Constable and K. Hosler attended a meeting of the Technical Working Group on May 10.

Presentations on the AERIS model and the Nanticoke field study were made to visiting scientists from the World Health Organization on May 19.

T. Bulman was at the WTC from June 12-16. She and K. Hosler are preparing the Volume 7 report for submission to John Matthews (U.S. EPA) by July 31.

STATUS REPORT - SEPTEMBER 1989

T. Constable and K. Hosler met with B. Stiebel at the Monenco offices on August 25 to review the contents and structure of the Volume 7 report. Completion of some sections of the report is behind schedule because of delays in receiving some analytical data and because of time delays in corresponding with T. Bulman in Australia.

All analytical results for samples collected during the field studies have been submitted to Monenco for inclusion in Volume 7. The 14C content analytical results for soil samples from the repeat microcosm study were not received until the end of September. The section of the report dealing with this study is currently being written by K. Hosler, and will be submitted by October 20 to T. Bulman for review.

Drafts of the sections of the report dealing with Part II of the kinetic/incubation study and the RITZ and V.I.P. model evaluations were prepared by K. Hosler and D. Rutherford, and are being reviewed by T. Bulman.

T. Constable attended a meeting of the National Site Decommissioning Steering Committee in Calgary on July 10.

STATUS REPORT - DECEMBER 1989

H.W. Campbell, T.W. Constable, W.H. Stiebel and K.R. Hosler met on October 31 to define further work requirements and contract deliverables and to establish an anticipated completion date. Completion of some sections of the report is behind schedule because of delays in receiving analytical data and because of time delays in corresponding with T. Bulman in Australia.

The draft write-up for the kinetic/incubation study for inclusion in the Volume 1 (Laboratory Studies) report was prepared by K.R. Hosler and reviewed by T.L. Bulman. T.L. Bulman is preparing the sections of the Volume 1 report dealing with the repeat microcosm study involving 14C content in soils.

Figures and data tables from the Year I interim report were reformatted for consistency with the Year II figures and tables. This included redrawing all the Year I graphs in Harvard Graphics format and standardizing all figure and table titles using a common font.

T.L. Bulman reviewed the additional modelling work (V.I.P. vapour flux plots) requested for the comparison of field-derived volatilization data with laboratory measurements, and prepared the section of the Volume 2 (Field Studies) report dealing with interpretation of the RITZ and V.I.P. model evaluations.

T. Constable and K. Hosler attended the U.S. EPA's Seminar on Site Characterization for Subsurface Remediations on November 27 and 28 in Lowell, MA.

STATUS REPORT - MARCH 1990

K.R. Hosler compiled all text, figures, data tables and supporting documentation for the draft Volume 2 (Field Studies) and Volume 3 (Appendices - Laboratory, Field and RITZ/VIP Modelling) reports. The reports have been reviewed by at the U.S. EPA and their comments have been received by Monenco. T. Bulman is currently reviewing and writing portions of the final reports, and expects to be completed by May 31.

Discussions were held with several interested parties about commercialization of the AERIS expert system.

DIVISION: RESIDUE MANAGEMENT **PROJECT MGR:** H.W. CAMPBELL

PROJECT NO: 68358 **TEL:** (416) 336-4717

TITLE: VOLATILE ORGANICS CONTROL IN INDUSTRIAL WASTE STREAMS

OBJECTIVE:

1) To investigate the use of pervaporation for the removal and concentration of VOC's from water.
2) To develop a pervaporation membrane.
3) To develop a pervaporation module.

RELEVANCE:

Many hazardous waste streams contain VOC's which can be emitted to the atmosphere during waste storage, treatment, and disposal. One way to minimize or eliminate these emissions is to pretreat hazardous wastes to remove these compounds.

WORK PLAN:

1) A bench-scale unit will be used to test various membranes and waste feeds.
2) Under a U/P from Zenon Environmental Inc. a pervaporation membrane and module will be developed. Performance testing will take place at the WTC.

STATUS REPORT - JUNE 1989

External support for hollow fibres will be needed as thick composite membranes may be beyond development at this point. These fibres may be woven to form a mesh which would provide external support.

Chris Lipski presented the paper "Removal of Volatile Organic Compounds from Water by Pervaporation", at the ACS Conference in Dallas on April 12, 1989.

Work on the Elmira Leachate report was completed. Very high separations were achieved for most compounds. The report showed that the Henry's law Constant of some components is very much affected by the presence of other components in the liquid.

Models of mass transfer coefficients for cross-flow outside of tubes were compared to models presented by several authors for heat transfer. A report was completed showing that the models have poor correlation.

STATUS REPORT - SEPTEMBER 1989

Sampling equipment was prepared for the testing of the River Road pervaporation field unit constructed by Zenon Environmental Inc. Problems with the chilling system have put off testing until the end of October. Testing this system which comprises a spiral wound membrane will provide good comparison against the hollow fibre system.

Pressure drop modules were constructed. Head-loss tests for three fibre configurations were completed. These tests confirmed the models available for estimating head-loss in similar flow patterns used in different applications. Modules included a bank of 3000 rods and arrays of screens with narrow and wide apertures.

Micro-tubing (two 7000 ft lengths of two different diameters) was purchased from Helix Medical (California) for the purpose of testing weavability.

Work on a model for estimating operating and capital costs of a hypothetical pervaporation system continued at Zenon. The model estimates the complete installed cost for 99% removal of TCE from water. This model considers the effect of membrane wall thickness, diameter, membrane configuration, inside or outside flow and temperature. The model will also be extended to other membrane materials (with permeability different to that of silicone rubber) to determine if other polymers exist that give better performance than silicone rubber.

The model indicates that the thickness of the silicone rubber coatings required to be most effective in pervaporation are too thick to be applied by available technologies. A literature review for membrane materials with good selective permeability for VOC's continued. This may offer a better material than silicone rubber for work in pervaporation.

STATUS REPORT - DECEMBER 1989

A report summarizing the study on the estimation of head-loss for modules with 3 fibre configurations was completed. Tests confirmed existing models.

Celgard micro-porous hollow fibres (polypropylene) are being tested to determine effectiveness as a support layer. Ease of application of a polymer coating and stability of the polypropylene support layer will be evaluated as part of the first generation pervaporation membrane.

Mini-modules were constructed. Potting materials have been obtained from several suppliers to determine the most appropriate potting material for use with the Celgard fibres.

The MTR pervaporation module was tested to determine the effectiveness of this module for the removal of trichloroethylene from water. This test with a spiral wound module and membrane with a thin selective layer will determine the applicability of models presently available for such systems. Results from this test will not be ready until mid-January.

Pierre Côté presented a paper entitled "A Technico-Economical Evaluation of Pervaporation for Water Treatment" in Fort Lauderdale at the Fourth International Conference on Pervaporation Processes in the Chemical Industry. Tubular and hollow fibre (with flow inside) were compared to spiral wound module systems. Comparison was based on operating costs with capital cost amortized over five years.

STATUS REPORT - MARCH 1990

Surface modification of Celgard fibres has begun.

Design of the module manufacturing components and the module commenced.

Some possible limitations regarding vacuum requirements for pervaporation have been addressed. The project budget will determine if testing vacuum design strategies will be possible (if required).

Poor reproducible estimation of TCE concentration (in water) has warranted another look at better available techniques for the measurement of TCE levels in water.

"The Use of Pervaporation for the Removal of Organic Contaminants from Water", was submitted to Environmental Progress for publication in the August 1990 Special Issue.

Abbas Zaidi is tentatively scheduled to present the poster display for WTC at the SITE (E.P.A.) program in Philadelphia in May.

DIVISION: RESIDUE MANAGEMENT **PROJECT MGR:** H.W. CAMPBELL

PROJECT NO: 68359 **TEL:** (416) 336-4717

TITLE: ENGINEERED BARRIERS FOR WASTE CONTAMINANT

OBJECTIVE:

1) To evaluate the effectiveness of natural and synthetic material liners to contain wastes.
2) To develop an engineered barrier that minimizes the rates of leaching from landfill, waste impoundment, lagoons, etc.

RELEVANCE:

Past work on waste leachability estimation and on solidification has illustrated the potential for groundwater contamination from various liquid and solid wastes stored or disposed of on land. This problem can be alleviated through the use of engineered barriers of liners. There is a need to evaluate the long-term migration rate through various natural and synthetic material engineered barriers. In addition there is a need to develop engineered barriers with low migration rates, flexibility and long life.

WORK PLAN:

1) Through a U/P with McMaster University (Dr. J. Kramer, Geology), a new barrier based on a proprietary WTC concept will be developed.
2) Under the co-operative agreement with ECN, a model of contaminant transport at interfaces and through engineered barriers will be developed.

STATUS REPORT - JUNE 1989

A progress meeting was held on April 17 to review progress on the McMaster U.P. Problems were encountered with cracking of the materials when the plug was formed due to the release of CO_2. The problem was corrected by changing the chemistry of the parent materials.

A meeting was held with ECN and McMaster on April 19. The modelling work by D. Hockley revealed the importance of using equal concentrations of parent material and the insensitivity of the system to the speciation of the parents.

A paper entitled "Chemical Interactions at a Waste/Waste Interface" was submitted to Environment Technology Letters for publication.

STATUS REPORT - SEPTEMBER 1989

A progress review meeting was held on July 28 to discuss recent results. The experiments to duplicate certain aspects of the ECN work were completed. Experiments conducted with Stelco BOF slag and ferric chloride resulted in an excellent seal. Arrangements were made to obtain phenol contaminated sand from GM foundries for possible use as a waste sand medium. Multiple approaches to the estimation of the quality of the seal including triaxial measurements, diffusion studies and centrifuge studies are being developed. A small scale field prototype experiment will be initiated shortly.

STATUS REPORT - DECEMBER 1989

A progress review meeting was held on October 26.

McMaster have been successful in producing good plugs with calcium phosphate, calcium silicate and calcium carbonate. Some success has also been achieved with iron oxide but the data is not yet complete. Work has been initiated to test the seals using a double gradient approach, ie., adding the tracer at opposite ends of the tubes to determine if the direction of flow has any impact. A technique is also being developed to assess the quality of the seal. The concept of breaking the seal in some of the tubes to see whether it will reform, was discussed. Tentative methods to accomplish this were suggested.

Using the techniques developed by McMaster, a liner/plug will be generated in a number of the column tests for OWMC. The liner will be placed between the salt ash and the underlying clay layer. Conductivity will be monitored in the clay layer to determine whether the salt is moving through the liner.

STATUS REPORT - MARCH 1990

A meeting was held in February with McMaster and ECN personnel. The comparison study between McMaster and ECN was discussed and differences resolved. It was agreed that ECN and McMaster would both set up tubes to be measured after longer periods of curing using alternative tracers such as phenols, lead and chrome.

Experiments were conducted to puncture seals and observe the re-sealing phenomenon. Using colour chemical dyes, it was demonstrated visually that re-sealing occurred in 30 - 60 minutes.

Studies to determine the optimum seal for the OWMC chloride ion system are nearing completion.

DIVISION: PHYSICAL/CHEMICAL PROCESSES **PROJECT MGR:** A. ZAIDI

PROJECT NO: 66573 **TEL:** (416) 336-4618

TITLE: TECHNOLOGIES FOR THE RECOVERY OF SPECIFIC CONTAMINANTS AND RECYCLE OF INDUSTRIAL EFFLUENTS

OBJECTIVE:

To ensure the availability of appropriate technology for recovering specific contaminants of concern from industrial effluents with emphasis on the recycle of treated effluents as process water. In 1989/90, the emphasis will be on organic chemicals, food processing and metal finishing industries.

RELEVANCE:

It is becoming more and more apparent that the use of effluent treatment technologies which transfer contaminants from one compartment (e.g. water) of the environment to another (e.g. air or land), is not providing adequate environmental protection. This work will identify and develop/demonstrate technologies which may be used for recovery and recycle of specific contaminants and wastewaters.

WORK PLAN:

1) Provide technical assistance/advice, as required to C&P-IPB and regional personnel, industry and other concerned agencies. This will include support to the Ontario MISA program and Environment Canada's Great Lakes Program.
2) Maintain knowledge of the latest developments in toxics removal by adsorption, and develop improved techniques for evaluating the adsorption process on bench and pilot scale.
3) Review published information and contact relevant industry and government officials to initiate a program for the recovery and recycle of water in the food processing industry by March 31, 1990. Also, publish report on the work conducted in 1988-89.
4) By March 31, 1990, complete a report on the opportunities and available technologies for the recovery and recycle of phenolic from industrial wastes.
5) Contact various metal finishing plants and other relevant people to develop a program for the recovery and recycle of heavy metals, cyanide and water in the metal finishing industry.

STATUS REPORT - JUNE 1989

The poster presentation on the use of activated carbon adsorption for treating wood preservation wastewaters was displayed at the PCAO Conference in Hamilton on April 24. The paper is undergoing revision and completion is expected in the second quarter.

The literature review on phenolic wastes was continued. Abstracts of the papers reviewed to date have been completed and a summary of the literature is being prepared. Completion is expected in the second quarter.

A proposal for the treatment of DND's aircraft paint stripping wastewater was prepared and presented at a meeting with Environment Canada, DND and DSS officials on May 25. Everyone was very enthusiastic about the proposal and DND will try to get final approval for the work as soon as possible. Samples of the paint stripping wastewater were sent to the WTC and submitted for preliminary characterisation.

STATUS REPORT - SEPTEMBER 1989

There was no significant activity on the phenolic wastes literature review. Abstracts of the papers reviewed to date have been completed and a summary of the literature is being prepared. Completion is expected later this year.

The paper on the use of activated carbon adsorption for treating wood preservation wastewaters has been completed. Sandra Kok was the technical reviewer. The paper is awaiting final release approval from the WTC and will then be submitted to the Water Pollution Research Journal of Canada.

A Memorandum of Understanding was sent to DND from the Wastewater Technology Centre for funding to carry out treatability studies on DND's paint stripping wastewaters. Final approval from DND has not been obtained yet but is expected shortly. Preliminary work is continuing on the project and includes wastewater characterization, selection of activated carbons for bench scale testing and contact with major airlines to find out how their paint stripping wastewater is treated. Technologies that are being looked into as treatment alternatives are adsorption, membrane filtration, air stripping and photooxidation.

STATUS REPORT - DECEMBER 1989

Phenolic Literature Review

Work on finalizing the phenolic literature review is ongoing.

DND Project

WTC has not yet received the funding from DND to carry out treatability studies on their paint stripping wastewaters. According to L. Cocks of DND, details of their internal project management have not been completely worked out. A letter was sent to col. Penney, Deputy Chief of Staff, Military Engineering pointing out the difficulties that the WTC is experiencing receiving the funding for this work, particularly since at the request of DND, preliminary work has been ongoing for months. The letter stated that unless official word is received from DND by mid-January, this work will not be pursued further.

The following preliminary work for the DND project has been ongoing this quarter:

1. A. Zaidi (WTC) and L. Whittle (WASTART) visited the paint stripping facilities in Edmonton during November. Included in this trip was a meeting with Separ in Calgary to discuss preliminary membrane filtration tests with a sample of the wastewater. DND has sent a drum of wastewater to Separ but the tests have not been conducted as yet.

2. A meeting was held between Union Carbide, UOP, A. Zaidi (WTC) and C. Ross (WASTART), at UOP's facility in Tarrytown, New York, at the beginning of November to discuss the application of UOP's silicalite molecular sieve for the removal of organics from the paint stripping wastewater. It was agreed that the WTC will be provided with any relevant liquid phase data to develop an experimental program for the silicalite. The testing will be carried out by WTC personnel or contractors and UOP will assist in the way of occasional brainstorming/troubleshooting sessions. The liquid phase data have not yet been supplied by UOP.

Wood Preservation Paper

Approval for the release of the paper on the use of activated carbon adsorption for treating wood preservation wastewaters has been received and the paper has been submitted to the Water Pollution Research journal of Canada for publication.

STATUS REPORT - MARCH 1990

Recovery and Recycle Opportunities for Phenolics in Industrial Effluents

Abstracts of the literature collected were prepared and a summary report was completed by WASTART Limited. Copies of the final report were received and accepted as of February 1990.

DND Project

Discussions continued with DND to secure funding for the project. Work started on summarizing the results of preliminary assessment of the problem. A draft report is expected to be completed by the end of the next quarter.

DIVISION: PHYSICAL/CHEMICAL PROCESSES **PROJECT MGR:** A. ZAIDI

PROJECT NO: 68573 **TEL:** (416) 336-4618

TITLE: TREATMENT OF PULP AND PAPER INDUSTRY EFFLUENTS BY ULTRAFILTRATION

OBJECTIVE:

The objective of this work is to evaluate ultrafiltration as a technology which may be suitable for treating wastewater for the pulp and paper industry. More specifically, this work will focus (1) on the treatment of bleach plant effluent from Kraft pulp mills, and (2) on the treatment of wastewater from CTMP mills. The objective of the research would be to test, develop and demonstrate the effectiveness of the membranes for removing toxic organics from the wastewater. It is expected that the end result of this research would be patentable technical information on membranes for these particular applications.

RELEVANCE:

The effluents from pulp and paper mills represent a considerable pollution problem. This is particularly true for the effluent of bleach plants for Kraft pulp. In this case, besides the colour, COD and TSS of the effluent, the discharge of chlorinated organic substances is the environmental problem gaining the most attention at the present time. The most common steps taken to reduce the discharge of TOCl (Total Organic Chlorine) are various types of internal modifications of the process such as: modified cooking, oxygen prebleaching and substitution of some of the chlorine by chlorine dioxide. Ultrafiltration is an alternative external treatment to reduce the toxicity of the effluents, which has already gained popularity in some countries (Sweden, Japan..). This work will assist the pulp and paper industry of this country in evaluating ultrafiltration as a technique for wastewater treatment, and in choosing the proper membrane/technology for these particular applications.

WORK PLAN:

1) By October 31, 1989, select six suitable commercially available membranes to be characterized and evaluated;
2) By October 31, 1989, select the test protocols for initial evaluation of the selected membranes;
3) By March 31, 1990, complete the initial membrane characterization and identify the membrane casting parameters which will likely provide a significantly better membrane;
4) By March 31, 1990, complete a draft report on the initial testing and evaluation of commercially available membranes for pulp and paper mills effluents;
5) By March 31, 1990, develop a detailed experimental program for final membrane evaluation and casting of a new membrane.

STATUS REPORT - DECEMBER 1989

State of the Art Review

A literature search was conducted on ultrafiltration and nanofiltration applications in the pulp and paper industry. National and international contacts were established with researchers involved in that field. In particular, an expert on that topic at the Pulp And Paper Research Institute of Canada (PAPRICAN) agreed to act as an external advisor for this project.

Definition of the Program and the Objectives

As a result of the preceding review, the objectives of the initial work were defined according to the needs/goals of the Ministry of the Environment and the pulp and paper industry. A technical steering committee was created to assess the progress of the research work.

Selection of Suitable Membranes

Following the literature review as well as contacts established with membrane manufacturers, twelve organic membranes were selected for the initial work of this project. The Industrial Membrane Research Institute will also provide its own membranes for the project. The criteria for selection of the membranes are as follows:

- membranes which have already been used for these applications in the world, and can therefore be seen as "standard"
- membranes newly produced or under development whose characteristics might be very suitable for this application.

Chemistry of the Effluents/Analytical Protocols

Analytical protocols suitable for the project were reviewed. data on the chemical composition of the target effluents were collected.

Industrial Membrane Research Institute (IMRI)

The IMRI led by Dr. Sourirajan of the University of Ottawa was contracted to perform the initial characterization work on the selected membranes. Besides standard protocols using standard solutes (dextrans, PEG), more specific protocols using model compounds from pulp and paper effluents will be used. The model compounds to be used have been selected and ordered.

A breakdown in the carbon analyzer slowed down the work performed in December, however two membranes have already been characterized using standard solutes. The carbon analyzer was repaired before the end of the year.

STATUS REPORT - MARCH 1990

No significant activity.

DIVISION: **PHYSICAL/CHEMICAL PROCESSES** **PROJECT MGR: D. AVERILL**

PROJECT NO: 68575 **TEL: (416) 336-4747**

TITLE: **PROCESS CONTROL AND UPGRADING OF EFFLUENT FILTRATION OPERATIONS**

OBJECTIVE:

To develop process control and monitoring strategies for granular media filters employed in either municipal or industrial wastewater treatment processes. (2) To develop a better understanding of filter design and operation procedures to refine the design of pilot scale and full scale filtration systems. (3) To optimize granular media filter systems for specific applications, including treatment of: municipal primary effluent; municipal secondary effluents (including enhanced phosphorus and trace contaminants removal); combined sewer overflows, and various industrial wastewaters, (e.g. mining wastewaters,produced water treatment).

RELEVANCE:

Granular media filtration is a solid/liquid separation operation used in the treatment of municipal and industrial wastewaters, the treatment of potable water, and in many industrial processes. Optimization of the many design and operational variables is a time-consuming task involving empirical procedures. Automatic control and data acquisition systems are essential to the improvement of design and operation methods. These systems will also improve mathematical modelling capabilities which will provide a better understanding of filtration mechanisms. The end product will be more efficient methods of designing and operating filters for specific tasks such as the removal of fine metallic precipitates from industrial effluents.

WORK PLAN:

1) Exploratory modelling was completed in FY 88/89 and work was initiated on specific research topics in conjunction with McMaster University. By March 31, 1990, mathematical modelling of particle transport, flocculation and filter headloss will be completed along with preparation of the appropriate documentation. This work is both a continuation of the filtration study and initiation of a program to develop a small particles capability at the Wastewater Technology Centre.
2) Technical assistance will be provided with respect to Project 88 and other projects as required.

STATUS REPORT - JUNE 1989

The study of precipitation and flocculation of iron hydroxide particles was continued. Flocculation modelling was continued, with emphasis placed on identification and elimination of numerical instability (see Proj. 90). A series of pilot scale filtration tests was undertaken for the headloss modelling phase of the study.

The fibre-optics probe (borescope) was received and work was initiated to adapt it for use in the pilot-scale filter. The remaining components of the new microscope were received but the still camera to be used with the microscope is still on order. The laser particle size analyzer was disabled in May by a power system failure and in June by an electronics problem.

STATUS REPORT - SEPTEMBER 1989

Two series of pilot scale filtration tests were conducted for the headloss modelling portion of the experimental program. Additional bench scale filtration tests were conducted for the determination of particle transport efficiencies and particle transport modelling was continued.

STATUS REPORT - DECEMBER 1989

The laser particle size analyzer was sent out for repair in October; it will not be available until mid-January. Data analysis and model development work were continued. Emphasis was placed on refinement of the pore-space flocculation component of the model.

STATUS REPORT - MARCH 1990

The laser particle size analyzer was received in February, following a lengthy repair period. The analyzer was found to be operating improperly and required additional service. Experimental work was resumed in March when 24-hour filtration runs were conducted over two weeks. Data analysis and model development work were continued.

DIVISION: PHYSICAL/CHEMICAL PROCESSES **PROJECT MGR:** D. VACHON

PROJECT NO: 68576 **TEL:** (416) 336-4558

TITLE: TREATMENT OF METAL FINISHING INDUSTRY EFFLUENTS

OBJECTIVE:

Develop and demonstrate innovative, technically feasible and cost effective options for the treatment of effluents from the metal finishing industry.

Provide technical support to C&P-IPB and Regional Offices, other federal and provincial agencies and industry in resolving water pollution problems related to the metal finishing industry.

RELEVANCE:

Effluents from metal finishing operations are toxic and cause serious environmental problems. Current wastewater treatment technologies must be evaluated and new and innovative strategies must be developed and demonstrated to reduce this environmental hazard.

WORK PLAN:

Specific activities to be undertaken in FY 1989/90 will include:

1) Provide advice and supervision to an unsolicited proposal addressing the use of "Total Residual Chlorine" for process control of the alkaline chlorination process (2 stage CN oxidation, i.e. both CN and CNO). Completion March 31, 1990.
2) Participate in a Working Group developing training manuals for water pollution reduction and wastewater treatment for the Metal Finishing Industry.
3) Provide technical support to C&P-IPB & Regional personnel, industry and others on related wastewater treatment problems.

STATUS REPORT - JUNE 1989

An amendment to the WASTART UP was approved in late March to include an investigation of sampling and analytical problems associated with the determination of cyanate concentrations in mining and metal finishing effluents. To date, bench scale work had been completed and a draft report prepared and reviewed. A revised final report is expected in the near future.

From the bench testing of the chlorine analyzers, three potential analyzers were identified for field testing and demonstration in the process train. The units are supplied by Wallace & Tiernan, Fischer & Porter and Enterra.

The process control algorithm has been completed and will be pre-tested shortly at WASTART's facilities in Guelph, prior to use and demonstration at the metal finisher. Transfer of the pilot test facilities to the metal finishing plant was delayed pending resolution of a concern of the metal finisher. Because of newspaper articles presenting the metal finisher as a significant environmental problem, the metal finisher's corporate headquarters in the United States has requested complete anonymity. This problem has been resolved and transfer of the pilot plant is anticipated in early August.

Following set-up and preliminary testing, initiation of pilot scale development and demonstration should occur in early September.

STATUS REPORT - SEPTEMBER 1989

The pilot scale facilities have been installed at the metal finisher's plant. Initial "debugging" problems have been resolved with the pilot facilities and the chlorine monitors. Operation of

the pilot scale treatment plant, complete with process control will begin in early October. The work is proceeding on schedule. The development and demonstration phases will be essentially complete by the end of the fiscal year.

STATUS REPORT - DECEMBER 1989

Work continued on data collection and development work on the pilot scale demonstration of process control of the alkaline chlorination of cyanide bearing effluents from metal finishing operations. Problems encountered with the operation of the two stage treatment system included a temporary suspension of the second stage treatment facilities (electrical problems) and incomplete cyanide oxidation. High nickel and cyanide concentrations have been observed in samples collected from the first stage of the pilot facilities indicating an insufficient retention time for oxidation in the first reactor. These problems are expected to be resolved by mid January, 1990.

STATUS REPORT - MARCH 1990

Work continued on data collection and development work on the pilot scale demonstration of process control of the alkaline chlorination of cyanide bearing effluents from metal finishing operations. Investigations were undertaken to assess high cyanide concentrations in the pilot plant effluent and their relationship to the high effluent nickel concentrations. Longer reaction retention times were found not to have a significant impact in reducing either the nickel or the cyanide concentrations.

During this quarter, WASTART personnel completed the intensive monitoring portion of the study. Staff of the metal finisher will assume the daily monitoring of the pilot scale demonstration phase of the study during the month of April.

DIVISION: PHYSICAL/CHEMICAL PROCESSES **PROJECT MGR:** D. VACHON

PROJECT NO: 68577 **TELEPHONE:** (416) 336-4558

TITLE: TREATMENT OF METAL CASTING INDUSTRY EFFLUENTS

OBJECTIVE:

Develop and demonstrate innovative, technically feasible and cost effective options for the treatment of effluents from the metal casting industry.

RELEVANCE:

Effluents from metal casting operations can be toxic and can cause serious environmental problems. Current wastewater treatment technologies must be evaluated and new and innovative strategies must be developed and demonstrated to reduce this environmental hazard.

WORK PLAN:

Specific activities to be undertaken in FY 1989/90 will include:

1) Conduct a critical review of literature on current best available technology for treating effluents from the metal casting industry.
2) Evaluate current treatment efficiency for the metal casting industry in Ontario.
3) Undertake bench-scale tests, (sensitivity, optimization and simulation) to examine design parameters to achieve best available technology economically achievable. This will be followed in subsequent years by pilot-scale studies and the assessment of conditions in full scale processes.

STATUS REPORT - JUNE 1989

Funding of this project through the MISA program has been proposed.

STATUS REPORT - SEPTEMBER 1989

No activity.

STATUS REPORT - DECEMBER 1989

No significant activities were under taken in this project area this quarter. It is anticipated that only limited work will be conducted until adequate resources are secured.

STATUS REPORT - MARCH 1990

No significant activities were under taken in this project area this quarter. It is anticipated that only limited work will be conducted in this area until resources are identified to expand the scope of the program.

DIVISION: PHYSICAL/CHEMICAL PROCESSES **PROJECT MGR:** A.ZAIDI

PROJECT NO: 68578 **TEL:** (416) 336-4618

TITLE: CHARACTERIZATION AND TREATMENT OF THE EFFLUENTS FROM EMULSION SHIPPING OF HEAVY OIL

OBJECTIVE:

To characterize the effluents from the water-emulsion based heavy oil piping processes being developed by some oil companies.
To evaluate the treatability of these effluents on bench scale tests at the Wastewater Technology Centre and in the field.
To demonstrate the most cost-effective treatment technology at pilot scale in the field.

RELEVANCE:

Currently, the heavy oil produced in Alberta and Saskatchewan is pumped to the refineries as a mixture of naphtha and heavy-oil. The use of naphtha reduces the viscosity of the oil and makes the pumping/piping of the heavy oil possible. Several oil companies (BP, Canadian Occidental, Shell, etc.) have developed techniques which will allow for the pumping/piping of the heavy oil as an oil-water emulsion/mixture. It is expected that the shortage of naphtha in the next three to five years will make these new techniques economically attractive for heavy oil transport, and that the refineries will have to treat substantial volumes of wastewater that will be generated when the oil is recovered from the oil-water emulsions/mixtures. Oil companies have requested assistance from the Wastewater Technology Centre to undertake the characterization/treatability work to minimize the environmental costs associated with the discharge of these wastewaters.

WORK PLAN:

1) By May 31, 1989 contact the relevant industry officials and review the available data to develop the sampling and analytical program.
2) By July 31, 1989 form a technical steering committee with representation by the relevant oil companies.
3) By September 30, 1989 arrange for the analysis of representative samples using the selected protocols.
4) By March 31, 1990 review the data and develop an experimental program for bench-scale treatability tests.

STATUS REPORT - JUNE 1989

Several meetings were held with the relevant oil company officials to reach agreement on a sampling/analysis schedule. A firm schedule, however, could not be developed due to uncertainties in the test work proposed by the oil companies. Discussions for cooperative work are continuing.

STATUS REPORT - SEPTEMBER 1989

Discussions continued with the oil industry to reach an agreement on the scope of and the schedule for characterization work. BP Oil requested, and were provided with a revised proposal for the work. They are considering funding the proposal next fiscal year.

STATUS REPORT - DECEMBER 1989

No significant activity.

STATUS REPORT - MARCH 1990

No significant activity.

Additional discussions will have to be held with the industry in the coming months to determine future activities. Negotiations are expected to be complete by mid-June.

DIVISION: PHYSICAL/CHEMICAL PROCESSES **PROJECT MGR:** D. VACHON

PROJECT NO: 68579 **TEL:** (416) 336-4558

TITLE: TREATMENT OF IRON AND STEEL MILL EFFLUENTS

OBJECTIVE:

Develop and demonstrate innovative, technically feasible and cost effective options for the treatment of effluents from the iron and steel industry.

RELEVANCE:

Effluents from iron and steel making operations can be toxic and can cause serious environmental problems. Current wastewater treatment technologies must be evaluated and cost efficient innovative strategies must be developed and demonstrated to reduce this environmental hazard.

WORK PLAN:

Specific activities to be undertaken in FY 1989/90 will include:

1) Conduct a critical review of literature on current best available technology for treating effluents from the iron and steel industry.
2) Evaluate current treatment efficiency for the industry in Ontario.
3) Undertake bench-scale tests, (sensitivity, optimization and simulation) to examine design parameters to achieve "model technology".
4) Undertake pilot-scale tests to optimize operational parameters for model treatment technology.
5) Evaluate technical feasibility and economics for full scale implementation of appropriate technologies.

STATUS REPORT - DECEMBER 1989

Activity in this project area was initiated this quarter. Discussions were held with MOE's MISA personnel and a proposal to conduct a joint study between MISA and the WTC addressing "model treatment technology" at iron and steel mills was accepted for financial support through the MISA initiative.

A meeting was held in November with representatives from MOE, MISA, DOE and the iron & steel industry (Stelco, Dofasco, Atlas, Ivaco, Lasco). The scope of the proposed MISA and WTC jointly funded study was discussed. Concerns were expressed about the data from the proposed process development and optimisation study being used in effluent regulation development for the iron and steel industry. Subsequently only limited activities have been conducted until an agreement between MISA and the iron and steel industry can be reached. A second meeting is planned for early in 1990 to confirm the scope of activities to be undertaken.

STATUS REPORT - MARCH 1990

Meetings were held in January and February with representatives from MOE, MISA, DOE and the iron & steel industry (Stelco, Dofasco, Atlas, Ivaco, Lasco) to discuss the objectives and approaches to be followed for the MISA/WTC jointly funded filtration study. The draft edition of the Phase 1 Working Document, summarizing the findings of the initial phase of the study (evaluation of background information) was prepared and distributed in late March for review.

During this past quarter, work was initiated on the construction of a mobile pilot scale filter treatment facility for this study.

DIVISION: PHYSICAL/CHEMICAL PROCESSES **PROJECT MGR:** A. ZAIDI

PROJECT NO: 68581 **TEL:** (416) 336-4618

TITLE: GOLD MINING EFFLUENT TREATMENT

OBJECTIVE:

1) To continue to collect and disseminate information on alternative technologies to treat gold mining effluents as well as undertake appropriate R&D to ensure that cost effective technologies are demonstrated for the treatment of gold mining effluents.
2) To provide technical advice and assistance to personnel from the C&P-Regions and IPB, industry and provincial and other government agencies, as required.

RELEVANCE:

The project is a continuation of the work from previous years and is designed to fill the knowledge/data gap in the application of alternative technologies to reduce the discharge of deleterious and toxic substances from gold mining and milling operations in Canada.

WORK PLAN:

1) By September 30, 1989, initiate work and secure funding for the development of an expert system for developing gold mill effluent treatment systems.
2) By March 31, 1990, complete the production of a professional quality cyanide analysis training video.
3) My March 31, 1990, complete and publish the reports on the performance of the Hemlo area gold mill effluent treatment systems.
4) By September 30, 1989, publish Equity Silver Mine report.
5) By March 31, 1989, complete a literature review on the status of cyanate destruction technologies, and initiate appropriate test work.
6) Natural degradation study. By March 31, 1990, complete the model development work currently underway.
7) Publish the Proceedings of two technology transfer seminars and assess the feasibility of holding a third one in the Province of Quebec.

STATUS REPORT - JUNE 1989

SO_2/Air Treatment

A draft of the QA/QC discussion for the Equity report has been completed and submitted for review.

Natural Degradation

A review of the mathematical computer model was done with regard to the equations and their coding. Further discussions are pending.

Hemlo Report

Copies of the final draft of the Hemlo report have been sent to the participating mines, to J. Hawley of the M.O.E. and to J. Scott of Environment Canada. Further polishing of the report may be pending.

H_2O_2 Report

The first draft of the introduction, background and objectives of the report has been completed. A preliminary list of Canadian H_2O_2 users has been compiled. This list, as well as an international list, is still being developed.

Expert System

Work continued on information and data collection for the knowledge bases of the expert system.

Freeze Desalination

Funding ($55,000) for the proposed report on freeze desalination has received approval by the MOE.

Metal Speciation

A proposal was submitted to the MOE for approval and funding to conduct a metal speciation study on gold mine tailings pond overflows.

Cyanide Video

A contract has been given to Elizabeth McGinley (Ballanchyne Consultants) for the management and production of a video on cyanide analysis. G. Takacs of VID VIDEO Productions was chosen to do the filming.

Cyanide Analytical Protocol

"Standard" cyanide analytical protocols have been received for review from various regional laboratories within Canada.

STATUS REPORT - SEPTEMBER 1989

SO_2/Air Treatment

Review of the final draft of the Equity report is still pending.

Natural Degradation

The mathematical computer model equations and their coding were reviewed by Bill Snodgrass, Mark Yendt and Betty Ou. Work was continued on repackaging the model to include an output report. Completion date is still pending.

Based on discussions with the MOE and the OMA, no further research will be done.

H_2O_2 Report

A list of Canadian and American gold mines has been compiled and verified for completeness and correctness by regional environmental offices and mining associations. A list of international users was provided by DuPont (Fred DeVries) and Interox (Neil Wilton). These lists are being continually updated. Site visits and sampling campaigns were conducted at La Mine Doyon, Rouyn-Noranda, Quebec and at Giant Yellowknife Mine, Yellowknife, NWT. Performance and analytical data from these sites is still being collected and studied.

Expert System

Work continued on information and data collection for the knowledge bases as well as user interface development of the expert system.

A response to the funding proposal submitted to MOE is still pending.

Cyanide Video

The cyanide video (film) was completed and viewed with subsequent minor edits to be performed in the future.

An accompanying brochure is presently being drafted. A list of other government laboratories that perform cyanide (total and weak acid dissociable) analyses will also be included in the brochure.

Salt Mining/Freeze Desalination Report

Information regarding the salt mining industry (locations, processes used) has been collected. A visit to the Canadian Salt Co. (Windsor, Ontario) was made in early July to view the salt processing method. Contacts were made with Ron Ellis (Facility Manager, Canadian Salt Company), Chris Gibson (District Manager, MOE), and Mark Dunsbier (Quality Control Supervisor, Sifto Salt Mines, Domtar). A number of other organizations and individuals were also contacted to establish the status of saline wastewater treatment problems.

A literature survey was completed and industrial contacts were made with regard to reverse osmosis and electrodialysis desalination technology. It was decided, however, that neither of these technologies was appropriate for the treatment of saline wastewaters.

Contacts were established with manufacturers of evaporation and freeze concentration technology. Wallace Johnson, Freeze Technology Corporation gave a presentation regarding freeze concentration technology in September at the WTC.

STATUS REPORT - DECEMBER 1989

SO_2/Air - Equity Silver Report

No significant activity.

Hemlo Report

Further edits to the text and tables were completed. The latest draft has been submitted to A. Zaidi for final review.

Natural Degradation

Final code changes to the model, including format of output report to be generated by the model have been completed by M. Yendt. Program review is pending.

H_2O_2 Report

Analyses of samples from the sampling campaigns conducted at Giant Yellowknife Mine (N.W.T.) and Doyon Mine (Quebec) were completed by the WTC laboratory. The first draft of the report was completed and is presently being reviewed. Draft copies were also sent to each of the participating mines that were visited for their review of the report (GYK, Doyon and Hope Brook Mine, Nfld.). Collection of information on international gold mines is being continued.

Expert System

Development of the expert system prototype continues. A stand alone package on Ontario regulations for the gold mining industry was completed.

Approval by the Ontario Ministry of the Environment of a revised proposal for funding is still pending.

Work was commenced on coding of the Merrill Crowe and the CIP processes.

Review of literature and various expert system demonstration packages was conducted. This work will be performed on a continuing basis.

Cyanide Video

The final version of the video was duplicated. Supplementary material such as the brochure, the brochure cover design and the video jacket label design were drafted and submitted to Stirling Print and Creative for printing. It was decided that the video will be distributed by the CAWPRC, c/o Bill Holton. A single page advertisement/order form describing this video mailed along with the proceedings from the 1989 gold mining seminars (Feb-Vancouver, March-Toronto).

Salt Mining/Freeze Desalination Report

Editing of the first draft of the first section of the desalination report, "Saline Wastewaters in the Salt Processing Industry", is in progress.

Cost estimates and technical information from suppliers of Freeze Concentration equipment and Vapour Compression Evaporation equipment are being collected.

The first draft of the second section of the report, "Technologies Suitable for the Treatment of High Saline Effluents", is in progress.

Regeneration of CN From Gold Mine Effluents Using Hollow Fibre Gas Membranes

Equipment for the bench scale work was ordered and received. Equipment set-up and calibration was started with experimental work expected to commence in January 1990.

Gold Mining Effluent Seminar Proceedings

The Proceedings of the two gold mining seminars held in 1989 was completed, forwarded for printing and received in November. Distribution was undertaken in December and will be completed by mid January 1990. Arrangements were made with the Canadian Association on Water Pollution Research and Control for the sale of copies of the Proceedings (after initial distribution to participants).

STATUS REPORT - MARCH 1990

SO_2/Air - Equity Silver Report

No significant activity.

Hemlo Report

A detailed review and edit of the main report and its appendices was initiated. This work is still in progress.

Natural Degradation

A prototype computer model entitled CITAP (Cyanide In Tailings Application Program) was completed. Run time copies were sent to J. Hawley (Ontario Ministry of the Environment) and J. Scott (Environ. Canada, Ottawa) for their perusal. A copy was also given to J. Schmidt for his review.

A list of experts involved with computer modelling of the natural degradation process is being compiled for future reference and contact.

H_2O_2 Report:

A report entitled "Evaluation of the Use of Hydrogen Peroxide for the Oxidation of Cyanide in Gold Mill Effluent" was completed by WASTART Ltd. for the WTC. A presentation of the results of this study was made in February at the 25th Canadian Symposium on Water Pollution. Future work will include the preparation of a paper based on the report.

Expert System

Knowledge base development was carried out for the GEMS1 (Gold Effluent Management System 1) expert system prototype. Knowledge bases completed to date, include: (1) a stand-alone Ontario regulations knowledge base, (2) an ore composition data base for the major gold producing regions in Ontario, (3) a series of six knowledge bases for gold mill effluent output estimation, and (4) a knowledge base for tailings pond size estimation.

Funding was received from the Artificial Intelligence (A\I) R&D fund, a federal program promoting the R&D of artificial intelligence projects. Support from the fund is expected to continue over a 3 year period. Further funding is also expected from the MOE-MISA program for the next fiscal year. Projected completion of the project is the end of 1993.

Cyanide Video

The training video on cyanide analyses was completed and is being distributed through CAWPRC. To date, 22 copies have been sold.

Cost quotations were obtained for the translation of this video from English to French. Based on these quotations and previous work done for the WTC, VID Video Productions in Brantford was chosen to complete the required video changes. Translation of the script, the brochure and the tape labels as well as the design of the brochure cover and labels will be performed by WTC staff. Work is scheduled to begin in May.

Salt Mining/Freeze Desalination Report

A report concerning the Desalination of Saline Wastewaters generated from the salt processing industry was prepared. The report consisted of three sections. The first section identified the characteristics of the saline wastewaters and the sections in the salt manufacturing operations which generated these wastewaters. The second section examined desalination technologies. A literature review concerning the application of the various desalination technologies (reverse osmosis, electrodialysis, evaporation and freeze concentration processes) for the treatment of wastewater generated from mining (in particular salt mining) operations was conducted. Researchinstitutes, manufacturers, and suppliers involved with the particular technologies were identified.

Examples of applications of the desalination technologies were provided and recommendations for the use of each technology for the treatment of saline wastewaters generated from the salt mining industry were made. The third section examined two of the selected desalination technologies in greater detail. Process flow descriptions, process flow diagrams along with capital and operating costs were provided for the two technologies. From this information a recommendation was made regarding the most suitable technology for the desalination of saline wastewaters generated by the salt manufacturing industry in Ontario.

A literature review concerning Liquid Membrane Technology was completed. The review included an extensive list of references, a brief summary of the papers cited, abstract cards along with the acquisition of some of the more relevant papers and books.

The Use of Hollow Fibre Gas Membranes for the Recovery of CN From Gold Mill Effluents

A study on the recovery of cyanide from gold mill effluents using hollow fibre gas membranes was initiated. This work will be performed by K. Maracle (McMaster University) under the supervision of P. Coté (Zenon) and A. Zaidi (WTC).

Bench-scale apparatus was set up and calibrated. Initial test runs were performed with synthetic aqueous NaCN solutions to study the membrane characteristics and to validate available literature data.

Future work will include test runs with synthetic metal cyanide solutions and actual milling waste barren solutions. A literature review of cyanide recovery processes will also be continued.

DIVISION: **PHYSICAL/CHEMICAL PROCESSES** **PROJECT MGR: A. ZAIDI**

PROJECT NO: 68582 **TEL: (416) 336-4618**

TITLE: **TREATMENT OF AQUEOUS EFFLUENTS FROM IN-SITU BITUMEN/HEAVY OIL RECOVERY**

OBJECTIVE:

To develop and demonstrate cost-effective technologies for the treatment of wastewaters from bitumen/heavy oil operations. Technologies will be such as to permit the recycling of wastewaters, or surface water discharge.

RELEVANCE:

Produced water associated with the recovery of heavy oil by in-situ techniques contains a number of undesirable constituents. These are (1) emulsified and free oil, (2) dissolved toxic organics, (3) dissolved metals (4) suspended inorganic and organic solids, and (5) dissolved inorganic salts. Treatment of the "produced" water is required such that it can be recycled for steam generation, or discharged to surface waters. Efforts to date have been made to treat this water using demulsification techniques followed by a complex series of treatment processes to remove other undesirable constituents. Significant deficiencies have been identified in the technologies employed to date. In 1989/90, the focus will be on field testing and demonstration of electrodialysis for TDS removal, other processes for oil and S.S. removal and in-house work on reverse osmosis.

WORK PLAN:

1) By March 31, 1990, finalize the characterization report on produced waters.
2) Hold a review meeting on all aspects of produced water treatment in cooperation with the Alberta Heavy Oil Association and other concerned parties.
3) Evaluate, on bench scale, silica removal by activated alumina, and by March 31, 1990, initiate work to pilot test the process if bench scale data show promise.
4) Provide support to IMRI, Ottawa, on work related to the testing of nano-filtration membranes for produced water treatment.
5) By March 31, 1990, reach agreement with Amoco and AOSTRA on a joint field study for evaluating microfiltration and hydrocyclones for oil and suspended solids removal, and oil-in-water monitors.
6) By September 30, 1989, reach agreement with Shell Oil and initiate work at Shell's Peace River site for performance evaluation of their oil removal processes.

STATUS REPORT - JUNE 1989

General

No monthly Management Committee meeting was held in May. Instead of a monthly Management Committee meeting, a telephone conference call was held in June. The participants were updated on the status of the field project.

Field Project

The VCE field report was received from the printers, and was distributed to the participants.

Characterization

No significant activity.

Oil and Suspended Solids Removal

A draft report on the performance evaluation work conducted at two heavy oil sites in Alberta was prepared and forwarded to the relevant oil companies. The results of this work were presented at the Annual Chemical Society Meeting in Dallas, Texas in April.

TDS Removal

Pretreatment

No significant progress was made on the ultrafiltration tests because the produced water generated at the field site with the limited steaming was not representative enough for the tests to proceed. This work is scheduled to restart on July 24.

Electrodialysis

Membrane characterization work which examines the long term stability of the membranes continued. Parameters analyzed for are ion exchange capacity, permselectivity and resistance under expected feed conditions continued. Analyses of the membranes after 100 days at pH 7, 10 and temperature of 25 and 60°C were completed. A summary report on the membrane characterization work was drafted.

Limiting current density experiments and concentration runs using Asahi Chemical membranes at 25°C were completed.

Visits were made to GKSS, and Berghof (supplier of ED systems in Germany). The experimental results were discussed and the experimental program was further developed.

STATUS REPORT - SEPTEMBER 1989

General

Management Committee meetings were held in August and September. The August meeting was held at the Amoco-Elk Point field site. The participants were presented with the results of the ultrafiltration trials, as well as the proposed experimental program on microfiltration and electrodialysis. A tour of the ultrafiltration and microfiltration units was also conducted. The decision was made to keep the ultrafiltration unit in the field for longer trials.

Field Project

The initial ultrafiltration pilot plant work was completed. The microfiltration pilot unit was started up. The microfiltration pilot unit was operated using two different size modules (0.8 and 1.2 micron). Preliminary examination of the permeate quality indicates similar quality as the ultrafiltration permeate in terms of oil and grease, and total suspended materials.

Visits were made to the site to relocate the workshop trailer and the prefabricated building, as well as the hookups for electrical and water supply. Discussions were held with Ray Orr, EP, Edmonton, on anticipated analytical requirements for the next three months.

Characterization

No significant activity.

Oil and Suspended Solids Removal

A draft of the final report on filtration process development for produced water (in-house study) was received from the contractor, Dearborn Environmental Consulting Group. The report was reviewed and returned to the contractor for revision. The report is expected to be completed by the end of the calendar year.

TDS Removal

Electrodialysis experiments with ultrafiltered produced water were started at the WTC. Analysis of the membrane characterization data was completed. The data indicated that the Asahi Chemical and Ionics membranes seem to be the best performing membranes at high temperatures. The Asahi Chemical membrane was used for the ultrafiltered produced water trials. Evaluation of current density was performed.

STATUS REPORT - DECEMBER 1989

AOSTRA/EC/Industry Produced Water Treatment Study

General

Management Committee meetings were held in October, November and December. The participants were presented with an update of the ultrafiltration and microfiltration trials and status of the electrodialysis program.

Field Project

All hook-ups for winter operations were completed. One electrodialysis unit was completely assembled.

Microfiltration and ultrafiltration tests continued. The microfiltration tests were being operated on an 8 hour per day, five day per week schedule. However, operations to accommodate a 24 hour day were being tried in December. The ultrafiltration unit was operated on a 24 hour per day, 7 day per week basis.

The electrodialysis experimental work was started; limiting current density and complete recycle runs were conducted for both UF and MF permeates. The results to date indicate that a higher limiting current density was obtained compared to the bench-scale work at the WTC.

Characterization

The characterization report was reviewed and is being finalized.

TDS Removal

Electrodialysis stack experiments with ultrafiltered produced water at the WTC were completed and the equipment was moved to the field. Membrane characterization work with actual produced water was completed.

STATUS REPORT - MARCH 1990

Oil Removal

A draft of a report entitled "Development of an Automated High-rate Filter for Treatment of Heavy Oil Recovery Produced Water" was received from Dearborn Environmental Consulting Group. This report describes the in-house process development work undertaken to prepare a pilot-scale filter for field demonstration.

AOSTRA/EC/Industry Produced Water Treatment Study

General

The Management Committee meeting was held in January only. The participants were presented with an update of the ultrafiltration and microfiltration trials and status of the electrodialysis program.

Field Work

Microfiltration and ultrafiltration tests ended in February. During this quarter, microfiltration operation was changed to 24-h/d, 5 d/week operation. Mechanical cleaning of the ultrafiltration modules (using sponge balls) was tested; mechanical problems ensued, leading to loss of 1 membrane module which was replaced. From mid January to the end of the tests, produced water quality had changed and contained high concentrations of surfactants which led to poor permeate quality and flux decline in both microfiltration and ultrafiltration permeates. The use of magnesium chloride as an aid in MF for surfactant-containing waters was tested.

The electrodialysis experimental work continued; concentration runs were conducted for both UF and MF permeates. The results to date indicated that both permeates performed similarly with respect to the nature of the fouling; therefore, microfiltration would likely be a better candidate for pretreatment because of higher fluxes. Post precipitation of solids from both permeates continued to be a problem; several oxidation and chemical process options were evaluated in March as a means to minimize this post precipitation.

The results of the bench-scale field work were being compiled and incorporated into a proposal to be presented to the Management Committee for decision-making for the pilot phase of the work.

Characterization

The characterization report on oil removal processes at commercial plants was reviewed and is being finalized.

TDS Removal

Membrane characterization work with actual produced water was extended to examine the effect of a longer time period of up to 350 days.

DIVISION: PHYSICAL/CHEMICAL PROCESSES **PROJECT MGR:** A. ZAIDI

PROJECT NO: 68583 **TEL:** (416) 336-4618

TITLE: EC/AOSTRA/INDUSTRY - LINDBERGH PRODUCED WATER TREATMENT STUDY

OBJECTIVE:

The objective is to evaluate, at pilot scale, in the Lindbergh area of Alberta, the technical and economic feasibility of electrodialysis for removing total dissolved solids and organics from produced water so that it may be recycled or discharged to the environment. In addition, evaluations of several unit operations for the removal of oil and suspended solids (pretreatment) will be undertaken.

RELEVANCE:

Produced water associated with the recovery of heavy oil by in-situ techniques contains a number of undesirable constituents. These are (1) emulsified and free oil, (2) dissolved toxic organics, (3) dissolved metals (4) suspended inorganic and organic solids, and (5) dissolved inorganic salts. Treatment of the "produced" water is required such that it can be recycled for steam generation, or discharged to surface waters. Efforts to date have been made to treat this water using demulsification techniques followed by a complex series of treatment processes to remove other undesirable constituents. Significant deficiencies have been identified in the technologies employed to date.

WORK PLAN:

1) By September 30, 1989, publish the summary report on the field evaluation of vapour compression evaporation.
2) By March 31, 1990, finalise and publish a performance evaluation report on the operation of IGF units at the B.P. and Suncor plants.
3) By September 30, 1989, complete the bench scale field evaluation of electrodialysis.
4) By September 30, 1989, complete the evaluation of ultrafiltration and microfiltration as pretreatment for electrodialysis.
5) By September 30, 1989, initiate work to pilot test electrodialysis in the field.

STATUS REPORT - JUNE 1989

See Project 82.

STATUS REPORT - MARCH 1990

See Project 82.

DIVISION: PHYSICAL/CHEMICAL PROCESSES **PROJECT MGR:** R. BOOTH

TEL: (416) 336-4726

PROJECT NO: 68586

TITLE: TREATMENT OF LEACHATE/CONTAMINATED GROUNDWATER FROM LANDFILLS AND INDUSTRIAL SITES

OBJECTIVE:

1) To assess the existing treatment technologies and develop and demonstrate technically feasible, cost effective technologies for the treatment of contaminated groundwater, soil and leachate from industrial sites and landfills.
2) To provide technical support to C&P, other federal and provincial agencies, industry and other practitioners in resolving groundwater and soil contamination problems.

RELEVANCE:

Contaminated groundwater and soil through poor waste management practices, leaking storage tanks and ponds, spills, etc., is a high priority environmental problem. The remediation of contaminated sites is extremely expensive and requires the application of efficient, site specific yet cost effective technologies. Many current remedial technologies need to be critically assessed and new and innovative technologies must be developed and demonstrated to resolve these problems.

WORK PLAN:

1) Provide leadership and management of the contract with SNC, University of Sherbrooke and Laval University on the remedial measures undertaken at Ville Mercier. Completion is expected by December 30, 1989.
2) Provide management of the contract with CANVIRO Consultants developing and demonstrating potential remedial measures for groundwater contamination at an organic chemicals plant (Uniroyal Chemicals - Elmira, Ontario). Completion is expected by mid 1990.
3) Provide technical assistance and advice to Transport Canada on the design and implementation of remedial measures at the Gloucester Site. Assist in the conduct of further field scale studies, as appropriate.
4) Develop or promote the development of innovative photo-oxidation technologies to treat contaminated groundwater.
5) By September 30, 1989, develop an experimental program for the development and demonstration of innovative, cost effective treatment technologies for volatile organics in the off gas from air stripping and soil venting operations. Conduct research as appropriate.
6) Provide technical support to C&P, OGD's and industry as required.
7) Participate in the NATO/CCMS Pilot Study on the Demonstration of Remedial Technologies for Contaminated Soils and Groundwater.

STATUS REPORT - JUNE 1989

Ville Mercier Site - Ville Mercier, Quebec

Bench and pilot-scale aeration and chemical oxidation experiments for iron pretreatment were completed. Pilot-scale experiments using aeration and granular media filtration, and aeration, flocculation, granular media filtration, and air stripping were also completed. The treatment train showing the best results to date is: aeration, filtration, air stripping, GAC adsorption and Mn greensand filtration. This treatment train is currently being tested on a continuous flow basis. Several minor modifications were made to the pilot plant to enhance sampling and operation.

A bench-scale study to determine the order of the ferric formation reaction was carried out .

- The interim report was reviewed and comments sent to SNC.
- In order to assess biological growth in the aeration column and filters, microscopic slides, obtained from the NWRI Microbiology Group, were installed in the aeration and filtration columns. Examination of the slides was made and considerable biological growth observed. Through consultation with Jim Dart, MOE, zinc granules were employed in the granular media filter bed to control growth.
- A residual oxidant measurement technique for use on-site was developed at WTC by D. Vachon and J. Brewer.
- Technical committee meetings were held on April 5th and May 31 in Mercier, and on May 1, 1989 at WTC.
- A management committee meeting, primarily to address additional contract funding, was held on May 30, 1989. Subsequent funding meetings were held with senior SNC staff (G. Fournier, L. Rancourt) and Raymond Perrier, Director, EP-Quebec Region.

Photo-Oxidation

A literature review was completed and the addresses of researchers involved in the photo-oxidation work were collected. A letter/questionnaire was distributed to determine the degree of interest in a photo-oxidation symposium. Since the response has been good, organization of the symposium was initiated. Assistance is being provided by Dr. John Carey, NWRI. high.

Innovative Technologies

A literature review on state-of-the-art and innovative technologies for the treatment of organics in the off-gases from air stripping and soil venting processes is continuing.

R. Booth met with NOVA research staff to discuss support for the development of an off-gas treatment process employing peat.

Gloucester Landfill Site - Gloucester, Ontario

Through discussion with WTC, MacLaren Plansearch have prepared a pretreatment pilot work proposal for submission to Transport Canada.

Uniroyal Site - Elmira, Ontario

Two Steering Committee meetings and several technical committee meetings were held over the last three months. It has been agreed to pursue biological treatment followed by GAC polishing and to coordinate work with the Environmental Emergencies Technology Division to evaluate UV/H_2O_2, reverse osmosis, steam stripping, and pervaporation on-site at pilot scale. Data on preliminary runs indicate that these processes show promise for treating or removing specific contaminants from the groundwater.

Considerable discussion took place between NWRI, Uniroyal, Canviro and WTC regarding an appropriate analytical procedure for Analine. Uniroyal investigated HPLC analysis. Canviro have developed an appropriate GC method.

The Phase 1 report was received and is under review.

Other Activities

The following seminars/conferences were attended:

- CSCE Environmental Division tour of Consumers Glass;
- NWWA Third National Outdoor Action Conference, Orlando, Florida;
- EPA 15th Annual Research Symposium, Cincinnati, Ohio;
- 9th Annual Ozone World Congress and Exhibition, New York, N.Y.;
- NHRI groundwater research symposium, Saskatoon, Saskatchewan

The following plant visits were made:

- Premier Peat Moss, Riviere-du-Loup, Quebec;
- Terrebone Water Treatment Plant, Terrebone, Quebec;
- Tricil, Mercier, Quebec;
- Stablex, Blaneville, Quebec.

Advice continues to be provided to C&P regional offices, OGD's, other levels of government and the private sector.

STATUS REPORT - SEPTEMBER, 1989

Ville Mercier

The three week full scale monitoring campaign and pilot work was successfully completed on-site by August 28, 1989. The two pilot plant trailers and lab trailer were then decommissioned. The pilot trailer containing the Aeration-Filtration-Stripping treatment train was sent to the Gloucester site. The pilot trailer, containing the chemical oxidation tanks, coagulation/flocculation units and GAC columns was returned to WTC, Burlington. The lab trailer, property of University of Sherbrooke, was sent back to the University. Data analysis, logging and plotting focusing on the full-scale sampling campaigns was initiated in the month of September for presentation at the NATO/CCMS meeting in November.

Time was also spent on historical data gathered on the full scale plant by the SNC Group during its 5 year operation, for the purpose of presentation at the NATO/CCMS meeting. Effort was also put into searching for a proper statistical method for data interpretation. The "Nalimov's Statistical Method for Determination of Outliers" using a 95% Confidence Interval was opted for.

Uniroyal Site - Elmira, Ontario

The Phase 1 tasks which included a technology literature assessment, bench scale biological PAC treatability work, technology selection and hydrogeological assessment work, were completed and a report prepared by CH2M Hill. The report was submitted, reviewed and comments returned to CH2M Hill to finalize the report.

A Steering Committee meeting and Treatment and Hydrogeological Technical committee meetings were held in August as was a special meeting with the Citizens Environmental Advisory Committee and other concerned local parties.

The biological pilot plant - a Sequential Batch Reactor - was purchased from Control and Metering, modified in accordance with WTC and CH2M Hill recommendations and received at WTC in late September for installation in the pilot plant trailer. A subsequent technical meeting was held between WTC and CH2M Hill personnel to finalize the pilot plant schematic and identify ancillary equipment requirements.

A series of four extraction wells and four reinjection wells were installed to determine the effectiveness of a purge and flushing scenario. During this extraction study DNAPL was found in one of the wells. The prime constituents were determined to be aniline, toluene and mercaptobenzothiozol.

Another series of wells will be established in a new location to see if DNAPL is present.

Batch adsorption tests and desorption column studies neared completion as did the regional and local groundwater contaminant modelling.

In September a second bench scale study to assess the benefit of PAC addition to biological treatment was initiated.

Gloucester

MacLaren Engineering in conjunction with WTC submitted a proposal to Transport Canada to undertake iron pretreatment pilot work on contaminated groundwater at the Gloucester site. Transport solicited comments from the Gloucester technical review committee, which were generally highly supportive. Discussions were held with Public Works Canada to alleviate some of their concerns over the need to do additional pilot scale work.

Although Transport is in favour of undertaking the work, the means of funding is unclear. However, in anticipation that a study will be undertaken, the iron pretreatment/air stripping trailer from the Ville Mercier site is being stored at the River Road Laboratory in Ottawa.

STATUS REPORT - DECEMBER 1989

Ville Mercier

Preparation of the final contract report by personnel from WTC, SNC, University of Laval and University of Sherbrooke, is underway.

Data from the full scale monitoring campaigns was entered into the computer and statistically evaluated. This information was used as the basis of a presentation at the NATO/CCMS Third International Meeting held in Montreal in November.

Meetings were held with MENVIQ to discuss the recommendations of the study in order to help them prepare a submission to the Quebec Treasury Board for future remediation work.

Uniroyal, Elmira.

The sequencing batch reactor (SBR) pilot plant assembly was completed and hydraulically tested.

Several treatment meetings were held to discuss design of the GAC effluent polishing system, the sampling program and the work plan for the EETD process equipment. A Steering Committee meeting was held in October.

A Citizen's Environmental Advisory Committee public meeting on DMNA in the Elmira drinking water was attended. Initial discussions on the treatability of DMNA were held with CH2M Hill.

Gloucester

No activity.

Other Activities

R. Booth made a presentation entitled Groundwater Remediation Initiatives in Canada at the First National CWWA Conference, Toronto, Dec 4&5.

R. Booth was a moderator at the NWWA/API Petroleum Hydrocarbons Conference in Houston, Texas from Nov 15 to 17.

J. Schmidt, M. Halevy and R. Booth attended the NATO/CCMS conference in Montreal, Nov 6 to 9. J. Schmidt was the official host and M. Halevy made a presentation on the evaluation of the groundwater treatment effort at Ville Mercier.

WTC Newsletter articles on GASReP and the Uniroyal project were prepared.

Preparation of a five year plan for groundwater and soil remediation was initiated.

Design of the Groundwater Laboratory was completed and construction is well underway.

STATUS REPORT - MARCH 1990

Ville Mercier

The NATO/CCMS paper was reviewed, revised and submitted to JACA Corporation for incorporation in the Proceedings of the Conference held in Montreal in November.

All the data from the project were entered into the computer in a finalized tabular format.

In January, a meeting was held with DSS, SNC, Laval and Sherbrooke Universities to discuss the financial aspects of the contract. These discussions are continuing.

In February, M. Halevy designed and undertook a sampling program at the Ville Mercier treatment plant, for MENVIQ, to determine the cause of erratic performance of the GAC columns observed between July and September of 1989. Residual oxidant determinations were done on site. VOC samples were sent to Lab. Services for analysis. The findings of this work will be included in the final report.

Comments were provided to MENVIQ on one of their internal memos on the treatment plant's operation and performance. Since the memo contained significant errors, WTC has agreed to provide comment on similar documents upon request from MENVIQ.

Preparation of the final report is on-going with completion scheduled for June 30, 1990.

Uniroyal

An information package on the health effects of DMNA received from Health & Welfare Canada and through a literature search by the Canadian Centre for Occupational Health and Safety and by Dr. Jack Rosenfeld, McMaster University was sent to Jeff Merriman of Uniroyal Chemical.

The site plan and pilot plant were completed and the pilot plant prepared for shipment to the site. However, delivery of the pilot plant to the site has been delayed due to a shut down at Uniroyal as a result of the high levels of DMNA in their effluent. The projected time for setup on site is now September. Contact with Uniroyal (J. Merriman) is being maintained.

A briefing note on WTCs activities at Uniroyal and in Elmira was prepared at the request of C&P - Ontario Region.

A medium pressure UV ozone system, destined to be used on the Uniroyal groundwater, arrived from Germany in March. The unit was wet tested at WTC and B. Lalonde trained on the operation of the unit by Dr. Lietska from Wedeco, Germany.

Elmira

Proposals were prepared for the DMNA Advanced Oxidation Processes treatability study, the photooxidation byproducts study and pilot study and submitted to CH2M Hill.

The bench-scale treatability study was completed. Using low pressure UV at 254 nm, DMNA concentration was reduced from 3 ppb to <10 ppt in 2.5 minutes.

A series of meetings were held with CH2M Hill and UV equipment vendors (Trojan, Aquafine, Wedeco) to discuss options for pilot and full scale systems based on preliminary WTC results.

A meeting was held with the Region of Waterloo and CH2M Hill to discuss pilot work at well E9, in Elmira. A proposal and work plan was prepared and work initiated.

A Wedeco 5B UV unit was set up in the field at one of the municipal supply wells in March. Runs with 187 nm and 250 nm lamps showed marginal difference. Preliminary data confirms flow rate predicted by bench studies. Exposure time and intensity studies will continue until the end of May.

Work has begun on the study of the identification of byproducts of the photoxidation of DMA.

Iron and Manganese

Discussions were held with the Regional Municipality of Waterloo (D. Stendal, R. McDonald) regarding a supply of groundwater with high iron and manganese. The Region welcomed the opportunity and will supply water from two wells in Kitchener.

A bench-scale aeration column was designed, built and hydraulically tested.

An experimental work plan was prepared by B. Lalonde and D. Vachon.

A groundwater sampling system employing an expandable/collapsible bladder was designed to minimize iron oxidation during the collection of large samples.

Great Lakes Activities

A meeting was attended on the GM plant in Messena, New York which was held by EP Ontario Region to brief technical support personnel on the Canadian review program for the site cleanup.

A meeting with EP-OR on Great Lakes sediments was attended. OR was briefed on GASReP and mutual points of interest discussed.

A workshop on contaminated sediments was attended and a presentation made on GASReP and it's relevance to the Great Lakes Cleanup Program.

Other Activities

A tour of the Gendron Lefebvre biologically activated carbon pilot plant at the City of Laval's Ste. Rose water treatment plant was taken by J. Schmidt, R. Booth and M. Halevy. M. Halevy attended a progress meeting on the contracted study.

Discussions were held with J. Weins (BC- MOE) and Richard Reis (SRG) concerning RD&D opportunities and priorities at the Pacific Place site in Vancouver. Based on these discussions a brief proposal on RD&D at the site was prepared for incorporation in the Canada/BC Environmental Technology Development and Demonstration Program.

M. Halevy made a presentation on WTC's groundwater remediation activities to the Canada-France Round table.

The paper entitled "Contaminated Groundwater Research Remediation Initiatives in Canada" was finalized and submitted to CWWA for final edit.

Presentations on GASReP, the Ville Mercier Aquifer Decontamination Study, the Demonstration of Groundwater Treatment Technologies at Uniroyal Chemical, and Groundwater Remediation at Gloucester were made at the Contaminated Land Assessment & Remediation Seminar, Jan. 23 & 24, Vancouver.

Organization of the bioremediation session of Bioqual '90, to be held in New Brunswick in November, was started.

J.W. Schmidt attended the NATO/CCMS meeting in Oslo, Norway during March. The Sydney Tar Ponds Site was proposed as the site of a second remedial demonstration technology and accepted by the Committee. The proceedings of the Third International Conference held in Montreal and hosted by Environment Canada have been received and are being distributed.

DIVISION: **PHYSICAL/CHEMICAL PROCESSES** **PROJECT MGR: R. BOOTH**

PROJECT NO: 68587 **TEL: (416) 336-4726**

TITLE: DEMONSTRATION OF GROUNDWATER TREATMENT TECHNOLOGIES FOR PROBLEMS OF THE PETROLEUM INDUSTRY

OBJECTIVE:

1) To conduct research, development and demonstration activities on technologies to resolve these problems.
2) To produce a manual of practice on such technologies and the means to prevent future problems.

RELEVANCE:

One of the environmental problems caused by the petroleum industry is the contamination of groundwater. Numerous cases of groundwater contamination caused by various means by this industry sector are on record.

A cooperative effort by PACE, CPA, representatives of the major petroleum companies, WTC and EMR to address these problems was initiated in 88/89. This initiative incorporates the formation of a national RD&D plan which identifies priority research areas, and the establishment of steering committees for scoping projects for the evolution of the plan and its implementation.

WORK PLAN:

1) By March 31, 1990, organize and participate in groundwater and soil remediation technology transfer conferences for the Upstream (exploration and production) and Downstream (refining, storage, distribution) sectors.
2) By April 31, 1989, establish the RD&D National Plan and priority area steering committees and participate in their deliberations.
3) By October 30, 1989, undertake a review of in-situ bioremediation and excavate and treat remedial technologies to establish a knowledge baseline, identify R&D needs and implement appropriate activities.
4) By September 30, 1989, initiate development and field demonstration of cost effective off-gas treatment technologies.
5) Assist in the development of a waste sites monitoring manual to be completed in 1990.
6) Assist IPB in a project to assess technologies for the remediation of hydrocarbon contaminated groundwater at sour gas plants.

STATUS REPORT - JUNE 1989

The Prevention and Treatment of Groundwater and Soil Contamination in Petroleum Exploration and Production was held in Calgary from May 9-11. R. Booth chaired the session on treatment technology.

On May 18, the inaugural meeting of the National R, D & D Steering Committee for hydrocarbon contaminated groundwater and soil remediation was held at WTC. The meeting was attended by representatives from PACE, CPA, NHRI, EMR, IPB, Alberta and Ontario MOE, and WTC. Participation by the other provinces has been solicited.

The second meeting of the In-situ Bioremediation and the Excavate and Treat Technical Subcommittees was held. Work is on-going by the University of Waterloo on the in-situ denitrification of benzene. This work is jointly funded by PACE and WTC (PERD).

Organization of the downstream (refining, distribution, storage) conference with IPB, EMR and PACE is continuing. An initial program has been prepared and additional sponsors (Provinces, API) are being sought.

A review of proposals for assessing treatment technology for remediating subsurface contamination at sour gas plants in Alberta was undertaken and an evaluation provided to CPA and IPB.

STATUS REPORT - SEPTEMBER, 1989

General

A proposal was submitted to CPA's-ERAC for joint support of the four literature reviews and research scoping studies to be done this fiscal year (In-situ Bioremediation, Off-Gas Treatment, Enhanced Volatilization Techniques, Excavation and Treatment Technologies). WTC will be notified in mid-November if funding is approved.

The Soil Venting and Off-Gas Technical Subcommittee met in September and focused support on three areas: the photo-oxidation symposium to be held in June 1990, off-gas treatment using peat and UV, and the enhanced volatilization technologies literature review and research scoping study.

The Excavate and Treat Technical Subcommittee also met in September. A presentation on the Aglofloat process was made by NRC, Alberta Research Council and EPRI (Electric Power Research Institute). Discussions focused on the proposed literature review/scoping study, a solvent extraction proposal from EETD, and a joint demonstration of the Aglofloat process with CPA next year.

Meetings were arranged in October for the Pump and Treat and In-Situ Bioremediation Technical Subcommittees and in early November for the Steering Committee.

In July, a presentation was made to PERD's Task 4.8 Generic Environment Committee on the research initiatives for 1990/91. The Committee recommended that an additional $150k be allocated to the groundwater area, subject to EMR (Brian Cooks') approval.

In August WTC and PACE personnel met with API representatives to discuss projects of mutual interest and APIs involvement in the national groundwater and soil remediation program. API will be represented on the Steering Committee by Bob Hockman of Amoco and on the subcommittees by either Bob or Bruce Bauman.

A "Guidelines for Proposals" document was prepared and circulated to Steering Committee members for review.

Invitations to participate in the program were sent to the provinces not already involved (NB, Nova Scotia, Newfoundland, Prince Edward Island, Saskatchewan, and Manitoba).

Organization of the "Downstream" Conference for October 1990 is continuing. API, EPA and the provinces were invited to sponsor the conference. A first sponsors meeting was arranged for mid-October.

Photo-Oxidation

Organization of a photo-oxidation symposium for June of 1990 continued with a meeting of the sponsors/steering committee and subsequent meeting with Marbek in July. Marbek have agreed to organize and run the symposium in a cost recovery mode so as to minimize WTC's sponsorship costs.

A brief meeting was held with John Carey, NWRI, in September and a second steering committee meeting arranged for late October.

A first draft of a literature review and research scoping study on state-of-the-art, innovative and developing technologies for the treatment of organics in the off-gases from air stripping and soil venting processes was completed. It was circulated to the Soil Venting and Off-Gas Treatment Subcommittee for review. A final report is due December 31, 1989.

STATUS REPORT - DECEMBER 1989

The second meeting of the GASReP Steering Committee was held in CPA's offices in Calgary at which time projects for 1990-91 were approved in principal.

Organization of the Conference "Prevention & Treatment of Groundwater & Soil Contamination in Petroleum Refining and Distribution" to be held in October, 1990 and on the Advanced Oxidation Processes symposium, scheduled for June 4 and 5 in Toronto, is continuing.

The literature reviews and research scoping studies on state-of-the-art and innovative technologies for the treatment of organics in the off-gases from air stripping and soil venting processes is continuing.

A research scoping study for in-situ volatilization technologies was awarded to CH2M Hill.

An in-situ bioremediation research scoping study was awarded to Beak Consultants.

Proposals for a research scoping study for "excavate and treat" technologies were reviewed.

The design of a field laboratory was completed and specifications prepared for tendering.

STATUS REPORT - MARCH 1990

Discussions are on-going with Dr. Jack Rosenfeld from McMaster University, Dr. Bill Cairns from Trojan and Dr. John Carey of NWRI on future collaboration on photo-oxidation studies on adsorbed compounds in the liquid and gas phases.

An update on the status and summary of the GASReP projects was prepared.

Participation on an organizing committee for a PACE workshop on contaminated soil treatment to be held May 7-9, 1990 in Winnipeg continues. Meetings in Toronto and Winnipeg were attended.

Quebec was formally reinvited to participate in GASReP.

Contracts were awarded through PACE to Ortech/Droycon for research into in-situ biological barriers and to Intera/Kenting for an "excavate and treat" literature review and research scoping study.

Work by various contractors on the literature review and scoping studies for in-situ bioremediation, in-situ volatilization and off-gas treatment are underway.

The final arrangements for the Advanced Oxidation Processes Conference, to be held June 4&5 in Toronto, are continuing.

"Excavate and Treat" and "In-situ Bio" Technical Subcommittee meetings were arranged and attended in Vancouver.

DIVISION: PHYSICAL/CHEMICAL PROCESSES **PROJECT MGR:** J. SCHMIDT

PROJECT NO: 68588 **TEL:** (416) 336-4541

TITLE: TECHNICAL SUPPORT: C&P-HQ AND REGIONAL OPERATIONS

OBJECTIVE:

To provide technical advice and assistance to C&P-HQ and Regional personnel involved with resolving pollution problems in the following areas of concern: (1) cleanup of the Sydney, N.S. tar ponds, (2) acidic drainage from mining operations and "acid slates", (3) International Joint Commission "areas of concern", and Great Lakes Water Quality Agreement activities (4) Fraser River Estuary projects, (5) C&P-OR/MOE initiatives concerning source control of industrial effluents generally, (MISA), (6) C&P-QR and Centre St. Lawrence initiatives, (7) WMD-IPB initiatives concerning hazardous waste management and (8) C&P-NWR initiatives with respect to tailings ponds at tar sands plants.

RELEVANCE:

Effective management of industrial wastewaters, particularly those containing toxic chemicals, is of concern to the Department.

WORK PLAN:

Provide technical advice, assistance and support as required to support relevant C&P activities (see also Project #68584).

STATUS REPORT - JUNE 1989

Support to the MOE's SUBET subcommittee on Industrial Unit Operations was continued.

Review of the draft report on the Syncrude tailings pond study was continued in support of the Alberta District Office.

STATUS REPORT - SEPTEMBER 1989

Two revisions of the report on filtration of the Syncrude tailings pond water were received from David Bromley Engineering and reviewed.

D. Vachon continued to provide support to the MOE's SUBET sub committee on Industrial Unit Operations. A preliminary review was completed of contractor proposals on the subject of the preparation of lecture material for a training course on Industrial Unit Operations under MOE's Sewer Use By-law Enforcement Program.

STATUS REPORT - DECEMBER 1989

The Alberta District Office has advised that the final report on the study of filtration of the Syncrude tar sands tailings pond effluent has been received from the contractor, David Bromley Engineering.

STATUS REPORT - MARCH 1990

The final report of the Alberta District project on filtration of Syncrude tailings pond water was received. "Research into the Use of Filtration for Tailings Pond Water Treatment" by David Bromley Engineering (1983) Ltd. describes the development of coagulation and upflow filtration operations for the treatment of a stable suspension of solid and semi-solid particles at concentrations greater than normally encountered in granular media filtration operations.

DIVISION: PHYSICAL/CHEMICAL PROCESSES **PROJECT MGR:** A. ZAIDI

PROJECT NO: 68589 **TEL:** (416) 336-4618

TITLE: TREATMENT OF WASTEWATER FROM OFFSHORE OIL PRODUCTION

OBJECTIVE:

The objective of this work is to evaluate alternative oil and suspended solids removal technologies which may be suitable for treating produced water from off-shore oil production/drilling facilities, and to develop/demonstrate the technology which may be most cost effective.

RELEVANCE:

Water produced during off-shore drilling and oil production contains significant amounts of oil and suspended solids. Usually, this water is discharged to the sea without proper treatment for oil removal. In some parts of the world (e.g. North Sea), the industry is being required to treat the water to remove oil and suspended solids. As off-shore drilling and production activity increases in Canada, the industry in this country will also have to provide proper treatment to the produced water. This work will assist the industry and the regulatory agencies in choosing the most cost effective technology for treating oily produced water from off-shore facilities.

WORK PLAN:

1) Complete the status report on oil removal processes operating at off-shore facilities by June 30, 1989. By June 30, 1989, form a project Technical Steering Committee with Mobil & Petro Canada and others, as appropriate.
2) By September 30, 1989, hold a review meeting with industry officials.
3) By September 30, 1989, complete the construction of pilot plant facilities for testing oil-in-water monitors.
4) By September 30, 1989, make arrangements with the suppliers of appropriate oil-in-water monitors and initiate an in-situ testing program.
5) By March 31, 1990, complete a draft report on the experimental work conducted on oil-in-water monitors during 1989-90.
6) By March 31, 1990, install and debug pilot-scale coalescers, hydrocyclones and microfilters for removing oil from off-shore produced water.

STATUS REPORT - JUNE 1989

Produced Water Characterization

Preliminary tests on the gravimetric protocol for determination of oil content have been completed.

Tests on oil droplet sizing were done using Horiba particle sizers based on light scattering techniques.

Oil-in-Water Monitors

Information on all available on-line oil-in-water monitors is being compiled. A total of 29 units have been incorporated into the database. Detailed information is now being collected on user experience with each of these units in order to facilitate the selection of monitors for our test program.

Some modifications have been made to the design of the test rig to facilitate on-line testing of the oil-in-water monitors.

Contacts

Visits were conducted to various facilities in the U.K. involved in produced water treatment work.

A meeting was held with Mr. Tim Hartman, Manager of the Orkney Water Test Centre. The OWTC is a privately funded centre and is currently conducting tests on two types of hydrocyclone, the Vortoil and the Dynaclean. The centre is also doing some comparative tests on various oil in water monitors.

A meeting was held with Mr. Phil Chown of BP Research Centre in Sunbury. BP is not currently doing test work on its coalescer system but is testing a new type of depth filter called the Kalsep Fibrotex Filter. BP is also contracting some hydrocyclone tests from the University of Southampton.

A four day visit was made to the University of Southampton to meet with Mr. Martin Thew and to work with Mr. Ian Nezhati on the hydrocyclone test rig. Canadian offshore crude was run through the rig to generate an emulsion and size the emulsion formed. Discussions were initiated with Martin Thew regarding the testing of Canadian crude oil on the Southampton test rig. A suitable experimental program was agreed upon. The cost was estimated at $25,000 and the time required at about three months. A detailed proposal will be supplied to the WTC by Mr. Thew in July.

STATUS REPORT - SEPTEMBER 1989

State of the Art Review

A survey was conducted last year among the major offshore operators in the North Sea. The responses provided details on the produced water treatment systems and monitoring techniques employed in the region. A summary of the results of the survey was prepared in draft form.

Produced Water Characterization

PetroCanada and Mobil Oil have provided crude oil samples from the Terra Nova and Hibernia offshore regions for the WTC test program.

Oil-in-Water Monitors

No significant progress.

Hydrocyclones

A review of available hydrocyclone technology for produced water treatment was conducted. Two static units, the CSPI (Conoco Special Products Inc.) Vortoil and the Merpro Montassa and one rotary unit, the Dynaclean (marketed by Serck Baker) were identified. The units effect separation of the oil and water by centrifugal forces generated by the swirling flow of the produced water. In the static units, a high pressure feed stream sets up the swirling flow. In the rotary unit, the swirling flow is established by mechanical rotation of the unit.

All three hydrocyclones are available for pilot scale testing in the U.K. A test proposal was submitted to each company and a cost estimate was obtained for the work. A verbal agreement is in place with Martin Thew of the University of Southampton for testing of the Vortoil unit with Canadian crude in January/February, 1989.

STATUS REPORT - DECEMBER 1989

Produced Water Characterization

Laboratory experiments are ongoing on evaluation of oil and grease analytical protocols. Offshore crude from Terra Nova is being used to generate a synthetic produced water. The tests have addressed the extraction efficiency of Freon 113, the precision and accuracy of the gravimetric method of quantifying the crude oil in the solvent extract and the use of silica gel to remove the more polar components of the oil.

Oil-in-Water Monitors

Work is continuing on updating and expanding the database on available oil-in-water monitors. There has been no significant progress in the construction of the monitor test rig.

Hydrocyclones

Tests of the static hydrocyclone at the University of Southampton are now scheduled to begin on February 26, 1990. The work will be conducted by Martin Thew over a four month period for a cost of approximately $35,000. Crude oil for the test work will be supplied by Petro Canada and a quantity of Terra Nova crude is already in the U.K.

Discussions are still ongoing with Dynaclean in the U.K. regarding details of the rotary hydroyclone test. The work is tentatively scheduled to begin in June.

Technical Steering Committee

A committee meeting was held on October 16 in Calgary. The monitor database and the North Sea survey were distributed. It was agreed that the WTC would complete a proposal for the offshore project and submit it to the committee members for their review.

The proposal was prepared and distributed to the members of the technical steering committee. It included details of the planned work on oil and grease analytical protocol development, on-line oil-in-water monitors, and static and rotary hydrocyclones. A contribution of $60,000 was requested from industry to support the work in 1990.

Another meeting was held on December 11 to review the proposal. The oil industry agreed to contribute providing there was equal contribution from 4 or 5 members of the technical steering committee.

STATUS REPORT - MARCH 1990

Produced Water Characterization

The most commonly used solvent for the analytical determination of oil in water is chlorofluorocarbon (CFC) 113. Under the Montreal Protocol, CFC 113 is expected to be phased out in Canada by 1999. Hydrochlorofluorocarbons (HCFC) have been proposed as alternatives to CFCs. These solvents have shorter lifetimes in the atmosphere than CFCs and therefore have lower ozone depletion potentials while still presenting a relatively low toxicity hazard for the experimenter. Although not yet commercially produced, samples of two HCFC products have been obtained from DuPont and Allied Signal for this study. Initial analytical test using the partition-gravimetric method indicated that the extraction efficiencies of the new solvents were similar to that of CFC 113. This work will be extended by using both colourimetric and spectrophotometric methods. In addition, a more extensive review of possible alternative solvents will be conducted. Work is also ongoing on the isolation of the suspended oil by treatment of the solvent extract with silica gel.

Oil-in-Water Monitors

A total of 36 units from 24 manufacturers have been identified as potentially suitable for offshore application and incorporated into a database. Measurement principles employed include light scatter and turbidity, solvent extraction and IR absorption, direct IR and UV absorption, UV fluorescence and ultrasonics.

The format of the monitor database was expanded to included more detailed information on the units. Copies of the data sheets assembled on the monitors were then distributed to the unit manufacturers. The manufacturers were requested to review the information and make any necessary corrections or comments. To date, responses have been received from 1/3 of the manufacturers.

Draft copies of the monitor database were distributed to members of the Technical Steering Committee.

Visits were made to the Department of National Defense in Ottawa and the Naval Engineering Test Establishment (NETE) in Laval. The Navy is very interested in the proposed WTC evaluation of several oil-in-water monitors and have had some monitor tests conducted at NETE in the past. As some delays have been encountered in the construction of a test rig at the WTC, it was suggested that the initial monitor tests could be conducted at NETE. Discussions are currently ongoing regarding this possibility.

Hydrocyclones

Tests of the CSPI Vortoil hydrocyclone at the University of Southampton were delayed due to difficulties in supplying samples of Canadian offshore crude oil. The work is now scheduled to begin in May, 1990.

Arrangements regarding testing of the Dynaclean hydrocyclone by Serck Baker in the U.K have not yet been finalized.

Technical Steering Committee

The meeting of the Technical Steering Committee was rescheduled from February to April to allow time for the WTC to contact some oil companies involved in Canadian offshore development who were not yet members of the Steering Committee. Current membership includes representatives from Petro-Canada, Amoco Canada, Husky Oil, Esso Resources, and Energy, Mines and Resources.

A meeting was held at the Amoco Naperville Research Centre in Illinois to determine whether the offshore project would complement any produced water treatment work ongoing at the Centre. A positive reaction was received to the WTC offshore project and it is anticipated that Amoco will provide some funding for this work.

A visit was made to Gulf Canada in Calgary to discuss possible cooperation in the Technical Steering Committee and it was agreed that a representative from Gulf would attend the next meeting.

A trip was made to Mobil Oil in Dallas to discuss the WTC project. A representative of Mobil from Calgary will attend the next meeting of the Steering Committee and Mobil will consider contributing to the study.

DIVISION: PHYSICAL/CHEMICAL PROCESSES **PROJECT MGR:** D. AVERILL
D. VACHON

PROJECT NO: 68590 **TEL:** (416) 336-4747/4558

TITLE: OPTIMIZATION OF CHEMICAL PRECIPITATION, COAGULATION AND FLOCCULATION OPERATIONS

OBJECTIVE:

1) Review flocculation theory and develop a predictive mathematical model.
2) Assess the impact of chemical precipitation and coagulation operations on the removal of contaminants from waters and wastewaters.
3) Investigate physical and chemical conditions which affect precipitation and coagulation operations and develop strategies for process optimization.
4) Optimize chemical precipitation and coagulation operations for the removal of phosphorus and other materials from municipal wastewaters.

RELEVANCE:

Chemical precipitation and coagulation operations are common to water and wastewater treatment processes. The efficiency of such processes is dependent on the physical and chemical conditions in the system. However, the hydraulic conditions in most full-scale plants are not conducive to optimum mixing and flocculation, and the traditional "jar test" procedures used for process design do not adequately model the system hydraulics. Ontario recently conducted a study of phosphorus removal, based primarily on monitoring full-scale plant performance with apparently little emphasis on fundamental design considerations. STPs discharging into Hamilton Harbour are considering sand filtration to improve treatment, but more cost effective methods may be realized by examining conditions within the plants. Quebec is implementing phosphorus removal in recently constructed and new plants; there is appreciable concern at the larger plants that optimum chemical usage be achieved. The removal of both organic and inorganic contaminants from water and wastewater would benefit from coagulation optimization and improved knowledge about the phase distribution of contaminants.

WORK PLAN:

1) Conduct laboratory experiments and develop flocculation simulation models.
2) Conduct laboratory experiments to examine the fate of specific contaminants in precipitation and coagulation operations.
3) Conduct a literature review and bench-scale tests of precipitation, coagulation and flocculation operations to identify appropriate methods for the design and operation of chemical addition systems.
4) Design, construct and operate a pilot-scale process to study mixing requirements and chemical effects. Coordinate with Project 91 with respect to instrumentation and process Control. (to continue in FY 1990/91).
5) Assess coagulation and flocculation conditions in full scale processes and provide support for process upgrading studies in support of GLWQA and St. Lawrence River clean up objectives.

STATUS REPORT - JUNE 1989

A stiff differential equation solution algorithm was coupled to the flocculation program and work was initiated on a multiple-species version of the algorithm. The inclusion of a variable porosity component in the flocculation algorithm appeared to correct the instability problem associated with the determination of product sizes. However, smoothing of the resultant particle size distribution curves was accompanied by distortions of the particle volume data.

Work is continuing on a compromise solution consisting of less variation in porosity and a greater number of particle size classes.

The development of a bench-scale filterability procedure to address chemically assisted media filtration of industrial effluents was initiated. The procedure was designed to assess the effects of headloss build-up, effluent quality and loading rates on filtration using different pretreatment coagulants. A bench scale unit was developed to regularly monitor headloss, effluent quality and loading rates. Preliminary testing of chemically assisted and non assisted filtration was conducted with a synthetic suspension of 30 µm silica. Further testing will assess the effects of varying media size and depth and filter loading rates.

STATUS REPORT - SEPTEMBER 1989

Work was continued on the multiple-species version of the flocculation algorithm and on the variable porosity option.

A third graduate student from McMaster University has initiated experimental work at the WTC. In-situ photographic techniques are being evaluated for the determination of particle size distributions involving large flocs.

A new instrument, the Photometric Dispersion Analyzer, was tested at bench scale as an initial step toward the development of process control systems for coagulation and flocculation operations.

Work continued on the development of a bench scale filterability test. Initial testing has been completed using a low hydraulic loading rate to the bench filter. A preliminary draft of these results was prepared by M. Charron (Ottawa Co-op student). The general finding from this phase of the work was, although differences between runs was observed, the loading rate for all tests was at the low end of typical levels. The usefulness of the procedure under these conditions is limited. Further work was proposed to look at the effect on bench scale filtration of significantly higher loading rates.

STATUS REPORT - DECEMBER 1989

Work was continued on the multiple-species version of the flocculation algorithm. The development of methods for observing floc particles in suspension was initiated. An extended abstract containing a status report on the project was submitted to the IAWPRC for inclusion in the proceedings of a forthcoming specialty conference. Specifications for a proposed image analysis system were completed but procurement was deferred by the reallocation of capital funds.

Additional tests were conducted with the Photoelectric Dispersion Analyzer and the bench scale filterability apparatus.

Work continued on the development of a bench scale filterability test. Testing of higher loading rates was conducted and results indicated that at high loading rates (>5 L/m^2•s) a filter bed depth of at least 50 cm was required. Headloss limits were raised from 0.5 m to 1.5 m to account for these higher rates and greater solids deposition in the filter.

Data from all the tests are being evaluated. Data from the bench scale unit was compared to results obtained from a pilot scale filter operated simultaneously under identical conditions. The similarity of the results appears to justify the use of the bench scale apparatus for screening purposes.

STATUS REPORT - MARCH 1990

Simulation modelling of the results from the bench scale filterability investigations was conducted this past quarter. In addition, a paper entitled "Development of a Bench Scale Protocol for Designing In-Depth Granular Media Filters" was submitted (and subsequently accepted) for presentation at the 1990 Annual CSCE Conference, to be held in Hamilton, Ontario in May.

Filterability index testing was undertaken and literature was reviewed as part of the development of a new methodology for bench-scale process development of granular media filtration operations.

A variable time-step version of the flocculation algorithm was developed. Flocculation experiments were conducted using in-situ videography with laser illumination of the flocs in conjunction with the on-line particle size analysis system.

DIVISION: PHYSICAL/CHEMICAL PROCESSES **PROJECT MGR:** D. VACHON
D. AVERILL

PROJECT NO: 68591 **TEL:** (416) 336-4747/4558

TITLE: EVALUATION OF INSTRUMENTATION FOR PROCESS CONTROL OF CHEMICAL PRECIPITATION, COAGULATION AND FLOCCULATION OPERATIONS

OBJECTIVE:

1) Evaluate on-line monitoring equipment for suspended solids, phosphorus, flow, etc. with regard to monitoring and controlling precipitation and coagulation operations.
2) Develop effective process control software to monitor and control precipitation and coagulation operations on-line.

RELEVANCE:

Chemical precipitation of phosphorus and other soluble pollutants is common to many municipal and industrial wastewater treatment processes. Chemical coagulation to enhance solid/liquid separation efficiency is usually required to remove the precipitates and/or colloidal particles originally present in the wastewater. Significant costs are often associated with chemical consumption and sludge production rates. In previous WTC studies it has been shown that precipitation, coagulation and flocculation operations may be improved by optimizing mixing conditions. However, significant savings may also be realized by controlling the chemical dosages with respect to changing wastewater conditions. Recent advances in instrumentation and low-cost digital control systems have made dosage control feasible. On-line monitoring of flow, suspended solids, phosphorus and possibly pH and/or alkalinity will be required for chemical dosage control. Some instrumentation requires thorough evaluation and the necessary process control algorithms need to be developed.

WORK PLAN:

1) Identify manufacturers of commercial on-line analyzers and evaluate existing specifications and performance data.
2) Develop bench and field scale test protocols to fully assess the performance of on-line analyzers.
3) Identify, select and obtain (loan) representative units to be tested.
4) Conduct the full evaluation of the selected analyzers based on the developed protocols.
5) Develop process control algorithms utilizing on-line data and test at pilot scale.
6) Evaluate the feasibility of full scale demonstration of process control of precipitation, coagulation and flocculation operations.

STATUS REPORT - JUNE 1989

No significant developments have taken place in this project area this past quarter. Assuming that more resources become available in the next quarter, more activity will be scheduled.

STATUS REPORT - SEPTEMBER 1989

No significant developments have taken place in this project area this past quarter. Assuming that more resources become available in the next quarter, more activity will be scheduled.

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STATUS REPORT - DECEMBER 1989

No significant developments have taken place in this project area this past quarter. Assuming that more resources become available in the next quarter, more activity will be scheduled.

STATUS REPORT - MARCH 1990

No significant developments have taken place in this project area this past quarter. Assuming that more resources become available in the next quarter, more activity will be scheduled.

NOTE: This quarterly becomes the base for the next ANNUAL REPORT - STATUS REPORT - MARCH 1990